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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 407

Contribution from the Office of Public Roads and Rural Engineering
LOGAN WALLER PAGE, Director

Washington, D. C. PROFESSIONAL PAPER November 10, 1916

PROGRESS REPORTS OF EXPERIMENTS IN DUST PREVENTION AND ROAD PRESERVATION, 1915

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NEW EXPERIMENTS.

The experiments begun by the Office of Public Roads and Rural Engineering during the year 1915 are all concerned with the use of bituminous materials in road construction, and include the construction of roads surfaced with bitumen and coralline rock, bitumen and sand, bituminous macadam by the penetration and mixing methods,[1]

[1] In the future publications of this office "bituminous macadam by the penetration method" will be called simply bituminous macadam, and "bituminous macadam by the mixing method" will be called bituminous concrete.

plain macadam with bituminous surface treatments, and bituminous concrete. Supplementary reports, describing the progress of experiments previously reported, follow the reports of the new experiments.

EXPERIMENTS ON MOUNT VERNON AVENUE ROAD, ALEXANDRIA COUNTY, VIRGINIA.

BITUMINOUS MACADAM (PENETRATION AND MIXING METHOD), BITUMINOUS GRAVEL CONCRETE.

This experimental project is located in general upon the Mount Vernon Avenue Road, in Alexandria County, Va. The entire project deals with the bituminous type of road construction. It begins at the Military Road, near the Arlington Cemetery, and extends on a new location to McKinley Street. Passing through McKinley Street to Columbia Pike, the road then follows a new location to the top of the hill near station 37+00, where it joins Mount Vernon Avenue. The old location of Mount Vernon Avenue is left again at station 85+00, and a new location is followed across Four Mile Run to Mount Vernon Avenue at approximately station 131+00. From there the road continues along Mount Vernon Avenue to Washington Avenue, thence through Washington Avenue and Washington Street to the city line of Alexandria. The total length of the project is 23,711 feet, or approximately 4.5 miles, and is divided into 20 experiments, as shown in Table 1. The experiments are numbered consecutively from the north end of the project toward Alexandria, and the experiments numbered 9 and 12 are identical in the construction methods employed.

The project naturally falls into three sections, according to the nature of the construction of the road base. Section I extends from the north end of the project (station −1+61) to station 153+00 at Hume, where the road crosses the tracks of the Washington-Virginia Railroad. A gravel base was laid throughout this entire section, both on the new location and on the old road, which was of earth and badly-worn gravel. Section II extends from station 153+50 to station 192+00. The base on this section is an old bituminous-macadam surface scarified and reshaped. Section III extends from station 192+00 to station 235+50, and the base is an old water-bound macadam surface, scarified and reshaped.

TABLE 1.—*Surface construction.*

	Experiment No.	Stone.	Bituminous material.	
			By penetration method.	By mixing method.
Section I	1	Sandstone	Fluxed native asphalt A	
	2	do	Oil-asphalt X	
	3	do		Fluxed native asphalt A.
	4	do		Oil-asphalt X.
	5	Gneiss	Fluxed native asphalt A	
	6	do	Oil-asphalt X	
	7	do		Oil-asphalt X.
	8	do		Fluxed native asphalt A.
	9	Gravel		Oil-asphalt Y.
	10	do		Fluxed native asphalt B.
	11	do		Refined tar.
	12	do		Oil-asphalt Y.
Section II	13	Trap	Oil-asphalt X	
	14	do	Fluxed native asphalt A	
	15	do		Fluxed native asphalt A.
	16	do		Oil-asphalt.
Section III	17	Granite	Fluxed native asphalt A	
	18	do	Oil-asphalt X	
	19	do		Oil-asphalt X.
	20	do		Fluxed native asphalt A.

Work was begun under contract February 25, 1915, and the project was finished December 6, 1915. A total of 20 working days was lost, owing to unfavorable weather and other causes. Of the total cost of $65,694.45 Alexandria County paid $33,696.21.

GENERAL FEATURES OF THE PROJECT.

Equipment.—The equipment available consisted of a steam shovel, 1,000 feet of industrial-railway track and cars, a pile driver, a mechanical scarifier, a semiportable road asphalt-mixing plant, three 500-gallon portable asphalt-heating kettles, a 10-ton macadam roller, an 8-ton tandem roller, an Emerson steam pump, 2 gasoline pumps and pipe, two 5-ton motor trucks, dump-bottom wagons, drag scrapers, plows, pouring pots, and hand tools.

Excavation.—Nearly all the excavation was done by steam shovel, and material was hauled to the fills by dump wagons. The industrial railway was not used to any extent. All fills were built in layers approximately 1 foot in thickness and rolled where possible. Side-hill slopes under new fills were thoroughly plowed. Slopes in cuts were finished 1:1 and on fills $1\frac{1}{2}$:1. The road was constructed 16 feet wide, with 4-foot shoulders, and the side ditches were excavated 19 inches below the grade of the road. The crown was $\frac{3}{8}$ inch to 1 foot on all sections. Of the total of 28,575 cubic yards of necessary excavation, 27,478 cubic yards occurred on section I between stations −1 +61 and 153 +00.

Drainage.—Subdrainage, culverts, and catch basins were built where needed. Ungalvanized corrugated-metal pipe culverts were placed as indicated in Table 2.

TABLE 2.—*Corrugated metal culverts.*

Material.	Coppered iron, station −2+00	Ingot iron, station 9+19	Coppered iron, station 9+43	Coppered steel, station 29+00	Open-hearth steel, station 74+87	Coppered steel, station 77+99	Ingot iron, station 80+94	Open-hearth steel, station 218+96
Diameter.....inches..	24	15	15	24	18	24	18	18
Analysis of metal:								
Carbon...per cent..	0.03	0.03	0.03	0.08	0.06	0.09	0.03	0.05
Sulphur..per cent..	.028	.030	.039	.046	.026	.053	.038	.029
Phosphorus, per cent.....	.0094	.009	.011	.030	.025	.0105	.012	.027
Manganese, per cent	.02	.015	.016	.37	.32	.38	.009	.31
Copper...per cent..	.16	.05	.16	.16	.016	.19	.06	.016

Concrete head walls were built for all pipe culverts and a concrete gutter was constructed on the right from station 29+00 to station 36+18 on a 4.92 per cent grade.

Four Mile Run Bridge.—It was necessary to build a new bridge over Four Mile Run at station 101+87. The design adopted for this bridge was of two 16-foot spans with 16-inch slabs. Work was commenced on the bridge March 6 and was finished June 6. The total cost was $3,332.56. Fifty-eight yellow pine piles were driven to a 20-ton theoretical bearing for the two abutments and the center pier foundations, which were built of concrete mixed in the proportions 1 : 2½ : 5. The foundations were begun 3 feet 4 inches below low water. No sheeting was used in the excavation for foundations and the pits were kept dry by the use of pumps. All concrete was mixed by hand on two large mixing platforms and a washed-gravel aggregate was used. Concrete for the slabs was of 1 : 2 : 4 mixture, and was reinforced with deformed bars. A railing was constructed of concrete with a mix of 1 part cement to 2½ parts of sharp sand.

All forms were constructed of dressed lumber and thoroughly braced. The forms for the bridge rail were oiled and other forms were kept wet during the placing of concrete. The rail was given three coats of a wash made as follows: 1 pound concentrated lye, 4 pounds alum, and 5 gallons of water, to which sufficient cement was added to make a wash that would spread with a large brush. The finished bridge has a clear width of 22 feet.

Foundation or base course.—On Section I an average interval of 60 days elapsed between the completion of excavation or rough grading and the commencement of subgrade construction and placing of gravel base. The subgrade was prepared exclusively by the use of picks and shovels, and the work was kept from three to five stations ahead of the gravel-base construction. All yielding and spongy areas were removed as rolling progressed and fresh material was supplied.

The gravel base, on this section, had an average compacted thickness of 6 inches, and was constructed of a sand-clay gravel, which

occurred in three pits adjacent to the road, namely, the Zimmerman pit near station 18+00, the Garfield pit near station 95+00, and the Haney pit 1,500 feet to the right of station 116+00. The free haul of gravel was fixed at 1 mile and overhaul was practically negligible. The gravel was excavated by means of a steam shovel and distributed in rows from dump-bottom wagons. Stones over 2½ inches in size were raked out at the pit or during the spreading. The gravel contained 8.5 per cent of water and weighed approximately 3,000 pounds to a cubic yard, measured loose in a dimensioned box. Gravel from the Zimmerman and Haney pits, which were cross-sectioned, increased about 20 per cent in volume when loosened. The loose depth necessary to obtain the requisite compacted depth of 6 inches averaged 7.92 inches and the weight per station averaged 58.5 tons. The spreading was controlled by means of 6-inch blocks and lines, and the gravel was rolled with a 10-ton roller. The mechanical analyses of the gravel are shown in Table 3.

TABLE 3.—*Mechanical analyses of gravel used for foundation course.*

	Zimmerman pit.	Garfield pit.	Haney pit.
	Per cent.	*Per cent.*	*Per cent.*
Passing 2-inch, retained on 1½-inch screen	11.2	.....	.....
Passing 1½-inch, retained on 1-inch screen	4.6	1.3	.....
Passing 1-inch, retained on ¾-inch screen	5.0	8.9	1.4
Passing ¾-inch, retained on ½-inch screen	9.1	11.3	15.7
Passing ½-inch, retained on ¼-inch screen	11.4	17.2	25.7
Passing ¼-inch, retained on $\frac{1}{10}$-inch screen	8.5	13.3	19.6
Passing 10-mesh, retained on 20-mesh screen	5.2	4.8	10.1
Passing 20-mesh, retained on 30-mesh screen	3.6	5.8	5.1
Passing 30-mesh, retained on 40-mesh screen	2.6	8.3	3.2
Passing 40-mesh, retained on 50-mesh screen	4.3	7.3	3.8
Passing 50-mesh, retained on 80-mesh screen	8.6	5.4	3.2
Passing 80-mesh, retained on 100-mesh screen	1.1	.5	.8
Passing 100-mesh, retained on 200-mesh screen	6.7	2.8	2.4
Passing 200-mesh screen	18.1	13.1	9.0
	100.0	100.0	100.0

The base of Section II (station 153+50 to station 192+00) was an old bituminous-macadam surface. It was scarified and reshaped without difficulty. Where excess material was found it was used to stiffen the shoulders immediately outside the new surface. Where a deficiency of material occurred, new 1½-inch broken trap rock (passing a 2½-inch screen and retained on a 1⅛-inch screen) was supplied. An average depth of about three-quarters of an inch of such stone was added to the penetration course continuously from station 153+50 to station 158+50, and from station 187+00 to station 190+50 a layer 4 inches deep, loose, was used to stiffen the base. The entire base, with added stone, was thoroughly rolled with a 10-ton roller.

The base of Section III (station 192+00 to station 235+50) was an old "water-bound" trap-rock macadam surface badly out of shape. It had apparently been repaired with limestone. It was

scarified and reshaped with some difficulty, as the left edge from station 221+00 to station 230+00 was 3 inches higher than the crown. From station 201+00 to station 208+89 and from station 215+28 to station 219+00 the old macadam was entirely removed to correct the profile and a new subgrade constructed. Six inches of "1½-inch" crushed granite (passing a 2½-inch screen and retained on a 1⅛-inch screen) was then placed. It was also necessary to add such stone to weak spots in the base between station 229+00 and station 234+00. The entire base was rolled with a 10-ton macadam roller. A gap of 639 feet occurs on this section at the viaduct over the Potomac railroad yards.

Shoulders.—Earth shoulders on Section I were constructed 4 feet wide with a slope of 1 inch to the foot, and they were finally trimmed and rolled upon completion of the work. On Section II 4-foot gravel shoulders of approximately 4 inches of compacted gravel from the Haney pit were constructed on both sides throughout the entire length. On Section III, from station 219+00 to station 235+50 similar gravel shoulders were constructed on both sides, except where a sufficient amount of material developed in the course of reshaping the old macadam with which to form a firm shoulder.

Cut-off.—Near station 2+50 a branch (or cut-off) was built for a distance of 230 feet along the southerly branch of the Washington-Virginia Railroad to allow traffic to pass through the new road and reach the Military Road going to Georgetown without twice crossing the railroad track. The surface of this cut-off was constructed as parts of experiments Nos. 1 and 2.

Right of way.—Approximately 10.2 acres of land were acquired by Alexandria County to provide for widening the old road and for the new right of way. All lands so acquired are marked at every point of curvature and tangency along the new right of way by means of concrete monuments.

Curves.—The reverse curve between stations 34+07 and 37+75 was widened gradually to a total width of 24 feet and suitably banked. The curve between stations 84+10 and 88+76 was widened gradually to a total width of 22 feet, and also suitably banked. The curve between stations 89+73 and 93+99 was also widened gradually to 22 feet.

Guard rail.—Wooden guard rails were constructed on Section I as follows:

From station 19+20 to station 34, left.
From station 20+26 to station 22+55, right.
From station 73+80 to station 81+64, right.
From station 74+24 to station 78+70, left.
From station 91+50, 3 panels on the right.
From station 98+70 to station 108+78, both sides.
At Hume Spring 4 panels of guard rail were erected.

The guard rail was built of red-cedar posts with two rails of yellow pine. The posts, which had been dipped in asphaltic material, were set 4 feet in the ground and sawed off 3 feet 3 inches above the surface. The 2-inch by 6-inch rails were given two coats of white lead and oil. The guard rail is set in each instance 3 feet outside the edge of the surfaced road.

Materials.—The materials used in all surface experiments were tested in the laboratories of the office and the results are given in Tables 4 to 9, inclusive.

TABLE 4.—*Physical properties of stone used in surface construction.*

Test.	Sandstone.	Gneiss.	Trap.	Granite.
Specific gravity	2.50	2.80	3.00	2.70
Weight per cubic foot.....pounds..	156	175	187	168
Water absorbed per cubic foot.....pounds..	.132	.28	.43	.328
Per cent of wear	4.8	3.0	2.6	3.0
French coefficient of wear	8.3	13.2	15.5	13.3
Hardness	15.5	18.8	18.3	18.7
Toughness	5	5	13	9

TABLE 5.—*Mechanical analyses of stone used in the bituminous-macadam by the penetration methods.*

	Sandstone.	Gneiss.	Trap.	Granite.
Over 2-inch screen	12.0	9.3	25.1	19.8
Passing 2-inch, retained on 1½-inch screen	55.1	59.9	47.2	57.7
Passing 1½-inch, retained on 1¼-inch screen	22.3	22.0	17.5	16.7
Passing 1¼-inch, retained on 1-inch screen	10.6	7.0	9.6	5.8
Passing 1-inch, retained on ¾-inch screen	.....	1.7	.5	.....
Passing ¾-inch, retained on ½-inch screen	.....	.....	.1	.....
	100.0	99.9	100.0	100.0

TABLE 6.—*Mechanical analyses of stone and gravel used in the bituminous macadam by the mixing method, and the bituminous-concrete.*

	Sandstone.	Gneiss.	Trap.	Granite.	Gravel.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Passing 2-inch, retained on 1½-inch screen	6.4	.....	22.4	1.8	.....
Passing 1½-inch, retained on 1¼-inch screen	12.1	6.9	35.4	24.4	.....
Passing 1¼-inch, retained on 1-inch screen	38.0	32.8	24.0	44.5	1.3
Passing 1-inch, retained on ¾-inch screen	29.5	29.5	15.0	13.5	8.9
Passing ¾-inch, retained on ½-inch screen	13.2	25.3	3.2	8.3	11.3
Passing ½-inch, retained on ¼-inch screen	.6	5.1	.....	6.3	17.2
Passing ¼-inch screen	.2	.4	.....	1.2	[1] 13.3
Passing 10-mesh, retained on 20-mesh screen	.....	.....	.....	.....	4.8
Passing 20-mesh, retained on 30-mesh screen	.....	.....	.....	.....	5.8
Passing 30-mesh, retained on 40-mesh screen	.....	.....	.....	.....	8.3
Passing 40-mesh, retained on 50-mesh screen	.....	.....	.....	.....	7.3
Passing 50-mesh, retained on 80-mesh screen	.....	.....	.....	.....	5.4
Passing 80-mesh, retained on 100-mesh screen	.....	.....	.....	.....	0.5
Passing 100-mesh, retained on 200-mesh screen	.....	.....	.....	.....	2.8
Passing 200-mesh screen	.....	.....	.....	.....	13.1
	100.0	100.0	100.0	100.0	100.0

[1] Retained on 10-mesh screen.

TABLE 7.—*Mechanical analyses of stone chips.*

	Sandstone.	Gneiss.	Trap.	Granite.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Passing 1½-inch, retained on 1-inch screen	.....	.....	.....	1.1
Passing 1-inch, retained on ¾-inch screen	.....	0.5	15.8	3.8
Passing ¾-inch, retained on ½-inch screen	2.0	6.1	25.8	35.7
Passing ½-inch, retained on ¼-inch screen	25.1	27.3	32.9	47.1
Passing ¼-inch, retained on $\frac{1}{10}$-inch screen	66.0	61.5	19.4	[1] 12.3
Passing $\frac{1}{10}$-inch screen	6.7	4.6	6.1	
	99.8	100.0	100.0	100.0

[1] Passing ¼-inch screen.

TABLE 8.—*Analyses of fluxed native asphalts and oil-asphalts.*

	Fluxed native asphalts.		Oil asphalts.	
	Specification A.	Specification B.	Specification X.	Specification Y.
	Experiment numbers 1, 3, 5, 8, 14, 15, 17, 20.	Experiment number 10.	Experiment numbers 2, 4, 6, 7, 13, 16, 18, 19.	Experiment numbers 9, 12.
Specific gravity 25°/25° C.	1.043	1.054	1.046	1.049
Melting point °C.	.....	.....	50.5	54
Penetration at 25° C., 100 grams, 5 seconds	117	71	102	74
Loss, 5 hours, 163° C., 20 grams ..... per cent.	2.36	2.60	0.25	0.12
Penetration of residue, as above	57	34	63	49
Per cent of total bitumen insoluble in 86° B. naphtha	23.45	24.50	26.79	28.28
Fixed carbon ..... per cent.	12.48	12.66	13.92	18.75
Soluble in CS_2 (total bitumen) ..... do.	96.65	96.86	99.90	99.92
Organic matter, insoluble ..... do.	1.17	1.07	0.07	0.05
Inorganic matter, insoluble ..... do.	2.18	2.07	0.03	0.03
Total	100.00	100.00	100.00	100.00

TABLE 9.—*Analysis of refined coal tar used in bituminous gravel concrete.*

Specific gravity 25° C/25° C	1.226
Float test 50° C	2′ 58″
Soluble in CS_2 (total bitumen), per cent	87.11
Free carbon, per cent	12.80
Inorganic residue upon ignition, per cent	0.09

Distillation (Engler flask).	Character.	By volume.	By weight.
		Per cent.	*Per cent.*
Water	.....	0.0	0.0
First light oils (to 110° C)	.....	0.0	0.0
Second light oils (110°–170° C)	.....	Trace.	Trace.
Heavy oils (170°–270° C.)	Solid	7.3	5.8
Heavy oils (270°–300° C.)	do	7.1	5.7
Pitch	Hard, brittle	85.6	88.5
		100.0	100.0

DESCRIPTION OF EXPERIMENTS.

Experiment No. 1.—Bituminous Macadam (Penetration Method); Sandstone with Fluxed Native Asphalt A.

Location: Station −(1+61) to station 5+00.
Total length: 661 feet.
Total area: 1,202.2 square yards.[1]

The compacted gravel base described above had been under traffic for 5 months before the experimental surface was begun. The base was generally smooth and hard, but a few depressions had developed; these were filled and the surface was cleaned and rolled. Three inches of 1½-inch crushed sandstone was then spread by shovels from piles along the road. The stone had the physical properties shown in Table 4 and the mechanical analysis shown in Table 5. Uniform spreading was accomplished by the use of 3-inch cubical blocks and all irregularities were subsequently brought to a true surface. A 10-ton macadam roller was used to compact this stone layer, except that whenever available an 8-ton tandem roller was used to advantage for this purpose. The bituminous material was a fluxed native asphalt of properties shown in Table 8. It was heated in 500-gallon kettles mounted on trucks. When the asphalt had reached a temperature of 300° to 350° F. it was drawn off into 3½-gallon hand-pouring pots and a uniform penetration coat of approximately 1.5 gallons to the square yard applied. While the oil was still hot clean stone chips were uniformly spread to fill the superficial voids and immediately rolled. The chips were broomed to an even distribution and excess chips removed as the rolling progressed.

A seal coat of hot asphalt approximately one-half gallon to the square yard was then similarily applied. Chips were then applied in such quantity as to leave a slight excess, and the surface was again rolled. The mechanical analysis of the sandstone chips is shown in Table 7. All the sandstone chips broke up immediately under rolling and traffic.

Experiment No. 2.—Bituminous Macadam (Penetration Method); Sandstone with Oil-Asphalt X.

Location: Station 5+00 to station 18+00.
Total length: 1,300 feet.
Total area: 2,599.7 square yards.[2]

The construction of this experiment was exactly as described for Experiment No. 1, except that the asphaltic material was an oil asphalt described in Table 8. A subdrain was constructed on the right from station 12+50 to station 18+25. It was built with 6-inch bell and spigot joint tile pipe laid 4 feet below the finished grade, and was covered to a depth of 12 inches with broken stone,

[1] Includes 27 square yards at end of cut-off. [2] Includes 289 square yards at beginning of cut-off.

on top of which was placed a 10-inch course of cobble stones. The drain was under the gutter line and was completed with a layer of earth.

EXPERIMENT NO. 3.—BITUMINOUS MACADAM (MIXING METHOD); SANDSTONE WITH FLUXED NATIVE ASPHALT A.

Location: Station 18+00 to station 28+10.
Length: 1,010 feet.
Total area: 1,867.8 square yards.

The compacted gravel base for this experiment had been under traffic about 4 months before the surface was laid. A thin layer of dust had developed and in a few instances the surface of the base was not true to section. The section was revised by hand picking, the addition of gravel to the hollows, and rolling. In general the base presented a smooth, hard appearance and was thoroughly swept with ordinary house brooms directly in advance of the placing of the bituminous macadam. The stone was ¾-inch sandstone with physical properties and mechanical analysis as shown in Tables 4 and 6, respectively. It was mixed with the hot bituminous material in the proportions of 38 pounds of asphalt to 600 pounds of stone in a semiportable mixing plant near station 95+00. The resulting percentage of asphalt to total weight of the mix was 5.95 per cent. The mix was hauled in dump-bottom wagons to the point of placing and dumped on spreading boards. It was spread at an average temperature of about 300° F. by shovels and rakes on the cleaned gravel base to produce a compacted depth of 2 inches.

The mixing plant raised the aggregate by means of a bucket-belt from a feeding pit into a heating cylinder, where it was heated. The heated aggregate was then elevated to a storage bin, from which it was run into a weighing hopper and thence into the mixing box. The asphalt was heated in two kettles, each of 1,000 gallons capacity, and dipped by ladles into a weighing kettle from which the hot material could be poured into the mixing box. The pouring began as the chute from the aggregate weighing hopper opened, while the blades of the mixer revolved continuously. A full minute was the minimum time of mixing, and the mixed material was then allowed to drop into the dump wagon.

The resulting mix was very satisfactory, as all the particles of aggregate were thoroughly coated. The temperature of the stone in the weighing hopper was constantly tested by the hand, and the temperature was checked at intervals by a thermometer, as was also the temperature of the asphalt. No separation of the mix occurred during the haul, and it arrived on the work almost without exception at a temperature above 220° F.

Immediately after the mixture was cooled sufficiently to avoid "waving," it was rolled with an 8-ton tandem roller. A seal coat of approximately one-half gallon of fluxed native asphalt A to the square yard was then applied by hand pouring pots, as described in experiments Nos. 1 and 2. Sandstone chips approximately free from dust, as indicated in the mechanical analysis of Table 7, were then spread uniformly in sufficient quantity to fill the superficial voids, and broomed with rattan brooms while the roller worked. A slight excess of chips was applied, which soon broke up into fine particles under traffic.

EXPERIMENT NO. 4.—BITUMINOUS MACADAM (MIXING METHOD); SANDSTONE WITH OIL-ASPHALT X.

Location: Station 28+10 to station 38+10.
Total length: 1,000 feet.
Total area: 1,924 square yards.

This experiment was exactly similar to experiment No. 3, except that oil-asphalt X of properties shown in Table 8 was used instead of fluxed native asphalt. The maximum grade on this section is 4.92 per cent.

EXPERIMENT NO. 5.—BITUMINOUS MACADAM (PENETRATION METHOD); GNEISS WITH FLUXED NATIVE ASPHALT A.

Location: Station 38+10 to station 50+45.
Total length: 1,235 feet.
Total area: 2,196.6 square yards.

This experiment was exactly similar to experiment No. 1, except that "1½-inch" gneiss was used instead of sandstone. The mechanical analysis of the crushed gneiss is shown in Table 5 and the physical properties of the stone in Table 4. The mechanical analysis of the chips used is shown in Table 7. The chips broke up into fine particles under traffic.

EXPERIMENT NO. 6.—BITUMINOUS MACADAM (PENETRATION METHOD); GNEISS WITH OIL-ASPHALT X.

Location: Station 50+45 to station 58+45.
Total length: 800 feet.
Total area: 1,422.2 square yards.

This experiment was exactly similar to experiment No. 5, except that oil-asphalt X was used instead of fluxed native asphalt.

EXPERIMENT NO. 7.—BITUMINOUS MACADAM (MIXING METHOD); GNEISS WITH OIL-ASPHALT X.

Location: Station 58+45 to station 71+78.
Length: 1,333 feet.
Total area: 2,369.8 square yards.

The crushed gneiss used in the bituminous mixture had the physical properties shown in Table 4 and of mechanical analysis shown in Table 6. The mechanical analysis of the gneiss chips used on this experiment is shown in Table 7. The experiment was otherwise exactly similar to experiment No. 4.

EXPERIMENT NO. 8.—BITUMINOUS MACADAM (MIXING METHOD); GNEISS WITH FLUXED NATIVE ASPHALT A.

Location: Station 71+78 to station 78+65.
Total length: 587 feet.
Total area: 1,221.3 square yards.

This experiment is exactly similar to experiment No. 7, except that fluxed native asphalt A, with properties as shown in Table 8, was used instead of the oil-asphalt.

EXPERIMENT NO. 9.—BITUMINOUS GRAVEL CONCRETE, PIT-RUN GRAVEL, WITH OIL-ASPHALT Y.

Location: Station 78+65 to station 89+50.
Total length: 1,095 feet.
Total area: 2,152.1 square yards.

TABLE 10.—*Typical analyses of oil-asphalt gravel mixtures used in experiment No. 9.*

	I.	II.	III.
	Per cent.	*Per cent.*	*Per cent.*
Bitumen soluble in CS^2	6.4	6.9	7.5
Mechanical analysis of aggregate:			
Passing 1-inch screen, retained on $\frac{3}{4}$-inch screen	5.7	6.7	4.4
Passing $\frac{3}{4}$-inch screen, retained on $\frac{1}{2}$-inch screen	16.9	11.4	12.8
Passing $\frac{1}{2}$-inch screen, retained on $\frac{1}{4}$-inch screen	17.1	19.9	18.6
Passing $\frac{1}{4}$-inch screen, retained on 10-mesh sieve	12.6	12.2	13.9
Passing 10-mesh sieve, retained on 20-mesh sieve	8.5	6.5	6.5
Passing 20-mesh sieve, retained on 30-mesh sieve	10.3	10.5	8.6
Passing 30-mesh sieve, retained on 40-mesh sieve	11.0	11.4	11.1
Passing 40-mesh sieve, retained on 50-mesh sieve	6.5	8.9	7.2
Passing 50-mesh sieve, retained on 80-mesh sieve	6.2	6.1	6.4
Passing 80-mesh sieve, retained on 100-mesh sieve	0.8	0.8	1.0
Passing 100-mesh sieve, retained on 200-mesh sieve	2.2	2.8	3.4
Passing 200-mesh sieve	2.2	2.8	6.1
Total	100.0	100.0	100.0

The gravel base for this experiment had been open to travel several weeks and was hard and smooth when surfacing commenced. Wherever small depressions or irregularities had developed they were corrected by hand picking and the application of new gravel, which was thoroughly rolled.

The gravel used for the aggregate in the bituminous concrete was a uniform dense gravel containing much fine material, as shown by

the mechanical analysis in Table 6. It was taken exclusively from the Garfield pit, where it was excavated by steam shovel and then hauled 1,000 feet to a storage pile near station 95+00. It was fed into the mixer through a 2-inch screen.

When the gravel was heated the clay formed a fine powder or dust and much of it blew away in dropping the material from the storage bin into the weighing hopper and from there into the mixing box.

The oil asphalt was mixed with the heated gravel in the proportions of 36.5 pounds to 500 pounds of gravel. The resulting percentage of bitumen by weight was approximately 6.8. Typical analyses of the mixture are given in Table 10.

The method of placing the bituminous gravel concrete was exactly as described for the bituminous mixed macadam experiments with stone aggregate. The depth of spreading was approximately 3 inches loose, and the compacted thickness was approximately 2 inches. The mix was allowed to set from 1 to 2 hours before rolling, to avoid a wavy surface.

The rolled surface before sealing presented a smooth, dense appearance, except for occasional small superficial pits. A seal coat of the same asphaltic material used in the mix was applied at a temperature of about 300° F. at the rate of one-half gallon to the square yard. Clean pea gravel was at once spread uniformly and the surface rolled. The maximum grade for this section is 5.24 per cent.

EXPERIMENT NO. 10.—BITUMINOUS GRAVEL CONCRETE. PIT-RUN GRAVEL WITH FLUXED NATIVE ASPHALT B.

Location: Station 89+50 to station 118+10.
Total length: 2,860 feet.
Total area: 5,445.2 square yards.

This experiment was constructed exactly as experiment No. 9, except that fluxed native asphalt B was used instead of oil asphalt. Typical analyses of the mixture are given in Table 11. The maximum grade is 4.08 per cent.

EXPERIMENT NO. 11.—BITUMINOUS GRAVEL CONCRETE. PIT-RUN GRAVEL WITH REFINED TAR.

Location: Station 118+10 to station 126+95.
Total length: 885 feet.
Total area: 1,573.3 square yards.

This experiment was constructed exactly as experiments Nos. 9 and 10, except that a refined tar was used throughout. The analysis of the tar is given in Table 9. The proportions of the mix were 43 pounds of tar to 500 pounds of gravel, which resulted in a percentage of 7.92 of tar to total weight of mixture. Typical analyses of the mixture are presented in Table 12.

TABLE 11.—*Analyses of typical samples of fluxed native asphalt gravel mix used in experiment No. 10.*

	I.	II.	III.
	Per cent.	*Per cent.*	*Per cent.*
Bitumen soluble in CS^2	6.39	7.11	7.26
Mineral aggregate:			
Passing 1½-inch screen, retained on 1-inch screen	.....	3.3	.....
Passing 1-inch screen, retained on ¾-inch screen	8.9	2.7	5.2
Passing ¾-inch screen, retained on ½-inch screen	7.5	12.7	9.9
Passing ½-inch screen, retained on ¼-inch screen	18.0	18.7	19.4
Passing ¼-inch screen, retained on 10-mesh sieve	13.4	12.1	14.5
Passing 10-mesh sieve, retained on 20-mesh sieve	7.0	5.9	7.3
Passing 20-mesh sieve, retained on 30-mesh sieve	8.8	8.0	11.5
Passing 30-mesh sieve, retained on 40-mesh sieve	11.1	11.2	13.4
Passing 40-mesh sieve, retained on 50-mesh sieve	9.3	7.4	7.3
Passing 50-mesh sieve, retained on 80-mesh sieve	6.3	7.2	5.8
Passing 80-mesh sieve, retained on 100-mesh sieve	1.8	.8	.8
Passing 100-mesh sieve, retained on 200-mesh sieve	3.2	3.3	2.1
Passing 200-mesh sieve	4.7	6.7	2.8
Total	100.0	100.0	100.0

TABLE 12.—*Typical analyses of tar-gravel mixtures used in experiment No. 11.*

	I.	II.
	Per cent.	*Per cent.*
Bitumen soluble in CS^2	7.1	7.6
Mineral aggregate:		
Passing 2-inch screen, retained on 1½-inch screen	.....	5.8
Passing 1½-inch screen, retained on 1¼-inch screen	.....	0.0
Passing 1¼-inch screen, retained on 1-inch screen	.....	4.0
Passing 1-inch screen, retained on ¾-inch screen	13.3	4.7
Passing ¾-inch screen, retained on ½-inch screen	11.4	9.7
Passing ½-inch screen, retained on ¼-inch screen	11.7	15.5
Passing ¼-inch screen, retained on 10-mesh sieve	13.1	12.5
Passing 10-mesh sieve, retained on 20-mesh sieve	8.5	7.2
Passing 20-mesh sieve, retained on 30-mesh sieve	9.6	9.6
Passing 30-mesh sieve, retained on 40-mesh sieve	11.0	10.6
Passing 40-mesh sieve, retained on 50-mesh sieve	8.5	8.1
Passing 50-mesh sieve, retained on 80-mesh sieve	6.1	5.9
Passing 80-mesh sieve, retained on 100-mesh sieve	1.1	.6
Passing 100-mesh sieve, retained on 200-mesh sieve	3.0	3.0
Passing 200-mesh sieve	2.7	2.8
Total	100.0	100.0

EXPERIMENT NO. 12.—BITUMINOUS GRAVEL CONCRETE. PIT-RUN GRAVEL WITH OIL-ASPHALT Y.

Location: Station 126+95 to station 153+00.
Total length: 2,605 feet.
Total area: 4,711.1 square yards.

This experiment was exactly the same as experiment No. 9.

EXPERIMENT NO. 13.—BITUMINOUS MACADAM (PENETRATION METHOD). TRAP ROCK WITH OIL-ASPHALT X.

Location: Station 153+50 to station 163+00.
Length: 950 feet.
Total area: 1,688.9 square yards.

The base for the surface experiment was an old bituminous-macadam road, which was scarified, reshaped, and rolled with a 10-ton roller. The old road crown varied from 2 to 6 inches, but was reshaped without difficulty. From stations 153+53 to 158+50

an extra depth of about three-fourths of an inch of trap was spread, so that the total depth of stone averaged nearly 4 inches loose. The "1½-inch" crushed trap used was of physical properties and mechanical analysis shown in Tables 4 and 5, respectively. The oil-asphalt analysis is given in Table 8. The mechanical analysis of the trap screenings or chips is shown in Table 7.

The experiment was constructed otherwise as previously described for the penetration macadam experiments with sandstone and gneiss.

EXPERIMENT NO. 14.—BITUMINOUS MACADAM (PENETRATION METHOD). TRAP ROCK WITH FLUXED NATIVE ASPHALT A.

Location: Station 163+00 to station 173+00.
Length: 1,000 feet.
Total area: 1,777.8 square yards.

This experiment was constructed exactly like experiment No. 13, except that fluxed native asphalt was used instead of oil asphalt, and that the extra depth of stone for the base was not required.

EXPERIMENT NO. 15.—BITUMINOUS MACADAM (MIXING METHOD). TRAP ROCK WITH FLUXED NATIVE ASPHALT A.

Location: Station 173+00 to station 182+80.
Total length: 980 feet.
Total area: 1,742.2 square feet.

This experiment was constructed on the same kind of base as experiments Nos. 13 and 14. Trap rock of physical properties and mechanical analysis shown in Tables 4 and 6, respectively, and trap chips of mechanical analysis shown in Table 7 were used. Otherwise the construction was similar to that of experiments Nos. 3 and 8. The mixing plant was located near station 215+00.

EXPERIMENT NO. 16.—BITUMINOUS MACADAM (MIXING METHOD). TRAP ROCK WITH OIL-ASPHALT X.

Location: Station 182+80 to station 192+00.
Length: 920 feet.
Total area: 1,621.4 square yards.

This experiment was constructed on the same kind of base as experiments Nos. 13, 14, and 15. From station 187+00 to station 190+50, 84.5 tons of "1½-inch" trap was added to the foundation in a uniform layer and rolled with a 10-ton roller. This spread stone was unfortunately traveled over for nearly 30 days and it became somewhat rounded before the surface was laid. It was necessary to replace the old pipe culvert at station 189+64, and bad weather during the progress of the work caused considerable settlement of the adjacent fill before the new culvert was completed.

The experiment was exactly like experiment No. 15, except that oil-asphalt was used instead of fluxed native asphalt. Mixing for the area between stations 182+80 and 192+00 was done at position

No. 2 of the mixing plant at station 95+00, and some bituminous material was lost in the long haul. The analysis of the fluxed native asphalt is shown in Table 8.

EXPERIMENT NO. 17.—BITUMINOUS MACADAM (PENETRATION METHOD). GRANITE WITH FLUXED NATIVE ASPHALT A.

Location: Station 192+00 to station 200+00.
Total length: 800 feet.
Total area: 1,422.2 square yards.

The base of this section consisted primarily of an old water-bound trap macadam road, which was scarified and reshaped. It was necessary to widen the old road an average of 2 feet. The added width of base was of "1½-inch" granite, which was also used to supplement a few weak spots in the old macadam base. The entire base was thoroughly rolled and compacted by a 10-ton roller. No binder was used.

The method of laying the surface in this experiment was exactly similar to that of experiment No. 13. The materials used, however, were fluxed native asphalt A and "1½-inch" granite. The properties of the asphalt are shown in Table 8, and the physical properties and mechanical analysis of the granite are shown in Tables 4 and 5, respectively. The mechanical analysis of the chips used is shown in Table 7.

EXPERIMENT NO. 18.—BITUMINOUS MACADAM (PENETRATION METHOD). GRANITE WITH OIL-ASPHALT X.

Location: Station 200+00 to station 208+89.
Total length: 889 feet.
Total area: 1,580.4 square yards.

The base of this experiment from stations 200+00 to 201+00 was similar to that described for experiment No. 17. From stations 201+00 to 208+89 the old macadam was entirely removed to revise the grade, and a base of "1½-inch" granite was laid to a loose depth of 6 inches and thoroughly compacted by a 10-ton macadam roller without the addition of any binder.

In other particulars this experiment was exactly similar to experiment No. 17, except that an oil-asphalt X was used with properties as shown in Table 8, instead of fluxed native asphalt.

EXPERIMENT NO. 19.—BITUMINOUS MACADAM (MIXING METHOD). GRANITE WITH OIL-ASPHALT X.

Location: Station 215+28 to station 225+10.
Total length: 982 feet.
Total area: 1,728 square yards.

The base of this experiment was an old water-bound trap-rock macadam road, rather badly out of shape. It was scarified and reshaped from station 219+00 to the end of the experiment. From stations

215+28 to 219+00 it was necessary to remove entirely the old macadam base to correct the profile, and a new base was built of "1½-inch" granite spread to a loose depth of 6 inches and rolled with a 10-ton roller until compacted, without the addition of any binder.

The surface was exactly similar to that in experiment No. 16, except that the stone was granite, with physical properties and mechanical analyses as shown in Tables 4 and 6, respectively. The mechanical analyses of the chips used are shown in Table No. 7. The percentage of the weight of asphalt to the total weight of asphalt and stone was 6.73. The mixing was done near station 215+00.

EXPERIMENT NO. 20.—BITUMINOUS MACADAM (MIXING METHOD). GRANITE WITH FLUXED NATIVE ASPHALT A.

Location: Station 225+10 to station 235+50.
Total length: 1,040 feet.
Total area: 1,866.7 square yards.

The base of this experiment was an old trap-rock water-bound macadam road, which was scarified and reshaped. Considerable extra stone ("1½-inch" granite) was added from stations 229+00 to 234+00 to supplement weak places in the old macadam.

The surface was laid exactly as in experiment No. 19, except that fluxed native asphalt of the analysis shown in Table 8 was used instead of oil-asphalt.

SUMMARY OF COST DATA FOR ENTIRE PROJECT.

The cost data for the experiments described above are presented in the tables which follow, Nos. 13 to 23.

TABLE 13.—*Cost data for subgrade.*

[Subgrade, stations —(1+61) to 235+50.]

Items.	Clearing and grubbing.	Excavation.	Shaping.	Scarifying and reshaping.	Rolling.	Subgrade, complete.
Quantity	*Acres.* 5.0000	*Cubic yards.* 28,575	*Square yds.* 45,835	*Square yds.* 11,378	*Square yds.* 57,213	*Square yds.* [1] 42,111
Labor	$125.57	$8,237.71	$3,035.83	$348.17	$72.74	$11,820.02
Materials	.....	287.05	.....	6.80	30.55	324.40
Total	125.57	8,524.76	3,035.83	354.97	103.29	12,144.42
Unit cost	*Acre.* $25.114	*Cubic yard.* $0.2983	*Square yard.* $0.0662	*Square yard.* $0.0312	*Square yard.* $0.0018	*Square yard.* $0.2884
Per cent of total cost	.22	15.24	5.42	.64	.19	21.71

[1] Does not include shoulders.

TABLE 14.—*Cost data for gravel shoulders.*

[Gravel shoulders, stations −(1+61) to 235+50.]

Items.	Gravel in pit.	Loosen and load.	Haul.	Spread.	Rolling.	Gravel shoulders complete.
Quantity	*Tons.* 984.59	*Tons.*	*Tons.*	*Square yds.* 5,220	*Square yds.* 5,220	*Square yds.* 5,220
Labor		$85.23	$293.07	$111.17	$7.50	$496.97
Materials	$65.64	5.10			3.15	73.89
Total	65.64	90.33	293.07	111.17	10.65	570.86
Cost per square yard	$0.0126	$0.0173	$0.0561	$0.0213	$0.0020	$0.1093
Per cent of total cost	.12	.17	.52	.20	.02	1.02

TABLE 15.—*Cost data for drainage structures.*

[Drainage, stations −(1+61) to 235+50.]

Items.	Concrete bridge.	Concrete culverts.	Pipe culverts.	French drain.	Cobble drain.	Open drain.	Concrete gutter.	Drainage system.
Quantity	*Cu. yds.* 219.22	*Cu. yds.* 127.87	*Linear ft.* 568	*Linear ft.* 705	*Linear ft.* 162	*Linear ft.* 1,850	*Cu. yds.*[1] 46.54	
Labor	$1,453.12	$738.16	$477.74	$508.39	$69.99	$116.42	$138.60	$3,502.42
Materials	1,879.44	897.95	684.08	217.73		22.60	173.27	3,875.07
Total	3,332.56	1,636.11	1,161.82	726.12	69.99	139.02	311.87	7,377.49
Per cent of total cost.	5.96	2.92	2.07	1.30	.12	.25	.56	13.18

[1] 718 linear feet.

TABLE 16.—*Cost data for incidentals.*

[Incidentals, stations −(1+61) to 235+50.]

Items.	Superintendence.	Equipment.	Extra work.	Guard rail.	Waste bitumen.	Miscellaneous.	Boundary stones.	Total.
Labor	$2,544.91		$709.84	$440.74	$16.49	$396.65	$42.16	$4,150.79
Materials			158.72	517.35	573.19	32.55	17.85	1,299.66
Interest, rental, depreciation		$3,120.71						3,120.71
Total	2,544.91	3,120.71	868.56	958.09	589.68	429.20	60.01	8,571.16
Per cent of total cost.	4.55	5.58	1.55	1.71	1.05	.76	.11	15.31

TABLE 17.—*Cost data for foundation course.*

[Foundation course, stations −(1+61) to 235+50.]

Items.	Material.	Loosen and load.	Haul.	Spread.	Rolling.	Foundation complete.
Quantity	*Tons.* 9,736.68	*Tons.* 1,675.32	*Tons.* 1,675.32	*Sq. yds.* 41,886.90	*Sq. yds.* 41,886.90	*Sq. yds.* 41,886.90
Labor		$807.94	$1,694.02	$756.01	$134.75	$3,392.72
Materials	$1,573.15	41.65			56.51	1,671.31
Total	1,573.15	849.59	1,694.02	756.01	191.26	5,064.03
Cost per square yard	0.0376	0.0203	0.0404	0.0180	0.0046	0.1209
Per cent of total cost	2.81	1.52	3.03	1.35	.35	9.06

TABLE 18.—*Cost data for surfacing.*

[Surfacing, stations −(1+61) to 235 +50.][1]

Items.	Stone on work.	Spreading stone.	Bitumen on work.	Application of bitumen.	Rolling.	Surfacing, complete.
	Tons.	*Tons.*	*Gallons.*	*Sq. yds.*	*Sq. yds.*	*Sq. yds.*
Quantity	5,735.68	5,735.68	90,557	42,111.90	42,111.90	42,111.90
Labor	$2,139.58	$944.82	$209.26	$3,588.30	$213.34	$7,095.30
Materials	6,601.98	.....	8,274.42	180.32	89.25	15,145.97
Total	8,741.56	944.82	8,483.68	3,768.62	302.59	22,241.27
	Ton.	*Ton.*	*Gallon.*	*Sq. yd.*	*Sq. yd.*	*Sq. yd.*
Unit cost	$1.5240	$0.1647	$0.0937	$0.0895	$0.0072	$0.5281
Per cent of total cost	15.62	1.69	15.16	6.73	.54	39.74

[1] Average over all experiments.

TABLE 19.—*Materials and cost data per square yard for bituminous macadam by the penetration method.*

Experiment No.	Station.	Description.				Quantity of material.		
		Stone.	Bitumen.	Length of section.	Area of section.	Stone.	Chips.	Bitumen.
				Feet.	*Sq. yards.*	*Tons.*	*Tons.*	*Gallons.*
1	−(1+61) to 5+00	Sandstone	Asphalt A	661	1,202.22	0.134	0.022	2.17
2	5+00 to 18+00	...do	Asphalt X	1,300	2,599.67	.134	.022	2.04
5	38+10 to 50+45	Gneiss	Asphalt A	1,235	2,195.56	.098	.018	2.03
6	50+45 to 58+45	...do	Asphalt X	800	1,422.22	.098	.018	2.12
13	153+00 to 163+00	Trap	...do	950	1,688.88	.122	.033	2.03
14	163+00 to 173+00	...do	Asphalt A	1,000	1,777.78	.122	.033	2.02
17	192+00 to 200+00	Granite	...do	800	1,422.22	.117	.025	2.12
18	200+00 to 208+89	...do	Asphalt X	889	1,580.45	.117	.025	1.92

Experiment No.	Station.	Cost per square yard (cents).							
		Stone on siding.	Unloading stone.	Hauling stone.	Spreading stone.	Chips on siding.	Unloading chips.	Hauling chips.	Spreading chips.
1	−(1+61) to 5+00	30.66	.....	8.61	1.45	5.11	.....	1.44	1.55
2	5+00 to 18+00	30.65	.....	8.60	1.43	5.11	.....	1.43	1.57
5	38+10 to 50+45	11.78	.....	1.89	.72	2.10	.....	.34	1.84
6	50+45 to 58+45	11.78	.....	1.90	.75	2.10	.....	.34	1.89
13	153+00 to 163+00	15.25	2.21	3.05	.89	6.14	0.60	.83	1.77
14	163+00 to 173+00	15.24	2.21	3.05	.89	6.14	.60	.83	1.78
17	192+00 to 200+00	16.75	1.89	4.10	1.91	3.55	.40	.87	1.24
18	200+00 to 208+89	16.75	1.90	4.11	1.91	3.56	.40	.87	1.25

Experiment No.	Station.	Cost per square yard (cents).						
		Bitumen on siding.	Hauling bitumen.	Loading and heating bitumen.	Applying bitumen.	Rolling penetration stone.	Rolling penetration and seal.	Total cost.
1	−(1+61) to 5+00	26.71	.50	1.70	1.78	.21	.41	80.13
2	5+00 to 18+00	13.27	.47	1.59	1.67	.22	.42	66.43
5	38+10 to 50+45	24.95	.47	1.26	1.85	.12	.42	47.74
6	50+45 to 58+45	13.78	.49	1.32	1.93	.13	.44	36.85
13	153+00 to 163+00	13.16	.47	1.29	1.50	.56	.69	48.41
14	163+00 to 173+00	25.51	.47	1.39	1.62	.56	.69	58.98
17	192+00 to 200+00	26.93	.49	1.71	2.02	.50	.68	63.04
18	200+00 to 208+89	12.52	.44	1.55	1.84	.50	.69	48.29

TABLE 20.—*Total materials and costs for bituminous macadam by the penetration method.*

Experiment No.	Station.	Description.				Quantity of material per square yard.		
		Stone.	Bitumen.	Length of section.	Area of section.	Stone.	Chips.	Bitumen.
				Feet.	*Sq. yds.*	*Tons.*	*Tons.*	*Gallons.*
1	−(1+61) to 5+00	Sandstone	Asphalt A	661	[1] 2,102.22	160.94	26.82	2,610
2	5+00 to 18+00	do	Asphalt X	1,300	[2] 2,599.67	348.00	58.00	5,310
5	38+10 to 50+45	Gneiss	Asphalt A	1,235	2,195.56	214.39	38.28	4,455
6	50+45 to 58+45	do	Asphalt X	800	1,422.22	138.82	24.79	3,015
13	153+00 to 163+00	Trap	do	950	1,688.88	206.07	56.02	3,420
14	163+00 to 173+00	do	Asphalt A	1,000	1,777.78	216.86	59.18	3,600
17	192+00 to 200+00	Granite	do	800	1,422.22	166.53	35.27	3,015
18	200+00 to 208+89	do	Asphalt X	889	1,580.45	185.02	39.28	3,044
	Total			7,635	13,889.00	1,636.63	337.64	28,469

Experiment No.	Station.	Total costs.							
		Stone on siding.	Unloading stone.	Hauling stone.	Spreading stone.	Chips on siding.	Unloading chips.	Hauling chips.	Spreading chips.
1	−(1+61) to 5+00	$368.55	.....	$103.42	$17.46	$61.42	.....	$17.34	$18.73
2	5+00 to 18+00	796.92	.....	223.53	37.09	132.82	.....	37.26	40.72
5	38+10 to 50+45	258.58	.....	41.65	15.71	46.06	.....	7.41	40.41
6	50+45 to 58+45	167.43	.....	27.07	10.69	29.83	.....	4.89	26.94
13	153+00 to 163+00	257.59	$37.32	51.49	15.04	103.64	$10.14	13.99	29.88
14	163+00 to 173+00	271.07	39.27	54.17	15.84	109.48	10.71	14.79	31.59
17	192+00 to 200+00	238.14	26.92	58.24	27.21	50.44	5.69	12.32	17.67
18	200+00 to 208+89	264.58	30.02	64.96	30.16	56.17	6.39	13.81	19.81
	Total	2,622.86	133.53	624.53	169.20	589.86	32.93	121.81	225.75

Experiment No.	Station.	Total costs.						
		Bitumen on siding.	Hauling bitumen.	Loading and heating bitumen.	Applying bitumen.	Rolling penetration, stone.	Rolling penetration and seal.	Total cost.
1	−(1+61) to 5+00	$321.03	$6.03	$20.41	$21.41	$2.52	$4.89	$963.21
2	5+00 to 18+00	345.15	12.27	41.43	43.48	5.64	10.88	1,727.19
5	38+10 to 50+45	547.97	10.29	27.74	40.53	2.67	9.28	1,048.30
6	50+45 to 58+45	195.97	6.97	18.81	27.47	1.78	6.19	524.04
13	153+00 to 163+00	222.30	7.90	21.81	25.35	9.51	11.67	817.63
14	163+00 to 173+00	453.60	8.32	24.70	28.75	10.01	12.30	1,084.60
17	192+00 to 200+00	382.91	6.97	24.25	28.79	7.07	9.74	896.36
18	200+00 to 208+89	197.86	7.03	24.43	29.01	7.84	10.85	762.92
	Total	2,666.79	65.78	203.58	244.79	47.04	75.80	7,824.25

[1] Includes 27 square yards end of cut-off north. [2] Includes 289 square yards end of cut-off south.

TABLE 21.—*Materials and cost data per square yard for bituminous macadam by the mixing method, and bituminous concrete surfaces.*

Experiment No.	Station.	Description.				Quantity of material per square yard.			
		Stone.	Bitumen.	Length of section.	Area of section.	Stone.	Chips.	Binder bitumen.	Seal bitumen.
				Feet.	*Sq. yds.*	*Tons.*	*Tons.*	*Gallons.*	*Gallons.*
3	18+00 to 28+10	Sandstone	Asphalt A..	1,010	1,867.78	0.143	0.020	1.66	0.48
4	28+10 to 38+10	...do.....	Asphalt X..	1,000	1,924.00	.137	.020	1.59	.51
7	58+45 to 71+78	Gneiss....	.....do.....	1,333	2,369.78	.108	.013	1.59	.51
8	71+78 to 78+65	...do.....	Asphalt A...	687	1,221.33	.108	.013	1.58	.52
9	78+65 to 89+50	Gravel....	Asphalt Y...	1,085	6,863.22	.140	.007	1.96	.50
12	126+95 to 153+00			2,605					
10	89+50 to 118+10	...do.....	Asphalt B...	2,860	2,445.22	.114	.007	1.54	.48
11	118+10 to 126+95	...do.....	Tar.....	885	1,573.34	.130	.007	1.79	.50
15	173+00 to 182+80	Trap.....	Asphalt A...	980	1,742.22	.118	.023	1.57	.50
16	182+80 to 192+00	...do.....	Asphalt X..	920	1,621.34	.119	.024	1.54	.46
19	215+28 to 225+10	Granite...	.....do.....	982	1,728.00	.085	.014	1.75	.56
20	225+10 to 235+50	...do.....	Asphalt A...	1,040	1,866.67	.085	.014	1.74	.51

Experiment No.	Station.	Cost per square yard (cents).							
		Stone on siding.	Unloading stone.	Hauling stone.	Chips on siding.	Unloading chips.	Hauling chips.	Binder bitumen on siding.	Hauling binder bitumen.	Seal bitumen on siding.
3	18+00 to 28+10	32.85	.....	9.18	4.65	.....	1.30	20.44	0.38	5.90
4	28+10 to 38+10	31.29	.....	8.78	4.55	.....	1.27	10.32	.37	3.31
7	58+45 to 71+78	13.54	.....	2.92	1.64	.....	.36	10.31	.36	3.31
8	71+78 to 78+65	13.55	.....	2.92	1.64	.....	.36	19.43	.37	6.40
9	78+65 to 89+50	.94	1.06	2.23	.76	.....	.74	11.56	.45	2.95
12	126+95 to 153+00									
10	89+50 to 118+10	.76	.86	1.80	.76	.....	.73	19.56	.36	6.10
11	118+10 to 126+95	.87	.98	2.05	.75	.....	.75	17.92	.41	5.00
15	173+00 to 182+80	17.08	1.96	1.22	4.32	0.39	.24	19.98	.36	6.35
16	182+80 to 192+00	17.19	1.98	1.23	4.36	.39	.24	10.02	.36	2.99
19	215+28 to 225+10	12.15	1.41	.....	1.98	.23	.31	11.34	.40	3.64
20	225+10 to 235+50	12.15	1.41	.....	1.98	.23	.31	22.10	.40	6.48

Experiment No.	Station.	Cost per square yard (cents).								
		Hauling seal bitumen.	Heating and mixing.	Hauling mix.	Spreading mix.	Rolling mix.	Applying seal bitumen.	Spreading chips.	Rolling seal.	Total cost.
3	18+00 to 28+10	0.11	6.38	5.26	1.19	0.24	0.55	0.52	0.08	88.98
4	28+10 to 38+10	.12	6.33	5.19	1.17	.32	.60	.54	.11	74.27
7	58+45 to 71+78	.12	6.77	3.02	1.02	.34	.91	.80	.15	45.57
8	71+78 to 78+65	.12	6.77	3.02	1.02	.33	.94	.80	.14	57.81
9	78+65 to 89+50	.12	7.02	2.71	1.17	.39	.84	.46	.14	33.54
12	126+95 to 153+00									
10	89+50 to 118+10	.11	7.02	2.71	1.17	.39	.82	.46	.13	43.74
11	118+10 to 126+95	.12	7.03	2.72	1.17	.40	.86	.45	.14	41.62
15	173+00 to 182+80	.12	6.57	4.50	1.12	.38	.50	.57	.11	65.77
16	182+80 to 192+00	.11	6.59	4.53	1.12	.38	.50	.57	.10	52.66
19	215+28 to 225+10	.13	10.05	5.51	2.98	1.09	1.67	.83	.54	54.26
20	225+10 to 235+50	.12	10.01	5.48	2.96	1.09	1.64	.83	.54	67.73

TABLE 22.—*Total materials and costs for bituminous macadam by the mixing method and bituminous concrete surfaces.*

Experiment No.	Station.	Description.				Quantity of material per square yard.			
		Stone.	Bitumen.	Length of section.	Area of section.	Stone.	Chips.	Binder bitumen.	Seal bitumen.
				Feet.	*Sq. yds.*	*Tons.*	*Tons.*	*Galls.*	*Galls.*
3	18+00 to 28+10	Sandstone	Asphalt A..	1,010	1,867.78	267.54	37.56	3,104	896
4	28+10 to 38+10	...do.....	Asphalt X.	1,000	1,924.00	262.92	38.22	3,055	981
7	58+45 to 71+78	Gneiss.....	.....do.....	1,333	2,369.78	256.70	31.64	3,759	1,208
8	71+78 to 78+65	...do.....	Asphalt A..	687	1,221.33	132.32	16.30	1,929	635
9	78+65 to 89+50	Gravel....	Asphalt Y.	1,085	6,863.22	969.60	47.09	13,442	3,431
12	126+95 to 153+00			2,605					
10	89+50 to 118+10	...do.....	Asphalt B..	2,860	5,445.22	618.20	37.23	8,388	2,614
11	118+10 to 126+95	...do.....	Tar.....	885	1,573.34	204.10	10.68	2,818	786
15	173+00 to 182+80	Trap.....	Asphalt A..	980	1,742.22	205.14	40.72	2,740	871
16	182+80 to 192+00	...do.....	Asphalt X.	920	1,621.34	192.18	38.07	2,500	746
19	215+28 to 225+10	Granite...	.....do.....	982	1,728.00	146.84	23.89	3,016	968
20	225+10 to 235+50	...do.....	Asphalt A..	1,040	1,866.67	158.66	25.81	3,249	952
	Total.....					3,414.20	347.21	48,000	14,088

Experiment No.	Station.	Total costs.								
		Stone on siding.	Unloading stone.	Hauling stone.	Chips on siding.	Unloading chips.	Hauling chips.	Binder bitumen on siding.	Hauling binder bitumen.	Seal bitumen on siding.
3	18+00 to 28+10	$613.67	.....	$171.50	$86.01	.....	$24.31	$381.79	$7.17	$110.21
4	28+10 to 38+10	602.09	.....	168.93	87.52	.....	24.51	198.58	7.06	63.76
7	58+45 to 71+78	320.87	.....	69.15	38.92	.....	8.68	244.29	8.69	78.52
8	71+78 to 78+65	165.41	.....	35.74	20.05	.....	4.36	237.27	4.46	78.10
9	78+65 to 89+50	64.64	$72.92	153.42	52.27	.....	50.59	793.08	31.06	202.43
12	126+95 to 153+00									
10	89+50 to 118+10	41.21	46.50	97.81	41.33	.....	39.82	1,065.15	19.38	331.98
11	118+10 to 126+95	13.61	15.35	32.31	11.85	.....	11.84	281.80	6.51	78.60
15	173+00 to 182+80	297.45	34.19	21.36	75.33	$6.79	4.18	347.98	6.33	110.62
16	182+80 to 192+00	278.66	32.03	20.02	70.43	6.35	3.92	162.50	5.78	48.49
19	215+28 to 225+10	209.98	24.34	.....	34.16	3.97	5.40	196.04	6.97	62.92
20	225+10 to 235+50	226.89	26.33	.....	36.91	4.31	5.85	412.62	7.51	120.90
	Total.....	2,834.48	251.66	770.24	554.78	21.42	183.46	4,321.10	110.92	1,286.53

Experiment No.	Station.	Total costs.								
		Hauling seal bitumen.	Heating and mixing.	Hauling mix.	Spreading mix.	Rolling mix.	Applying seal bitumen.	Spreading chips.	Rolling seal.	Total cost.
3	18+00 to 28+10	$2.07	$119.21	$98.21	$22.22	$4.47	$10.15	$9.63	$1.49	$1,662.11
4	28+10 to 38+10	2.27	121.77	99.79	22.58	6.18	11.55	10.32	2.06	1,428.97
7	58+45 to 71+78	2.79	160.39	71.65	24.15	7.99	21.51	18.98	3.53	1,080.11
8	71+78 to 78+65	1.47	82.63	36.91	12.44	3.99	11.46	9.78	1.76	705.83
9	78+65 to 89+50	7.93	481.88	185.98	80.53	27.10	57.78	31.44	9.24	2,302.29
12	126+95 to 153+00									
10	89+50 to 118+10	6.04	382.11	147.42	63.83	21.33	45.45	24.85	7.29	2,381.50
11	118+10 to 126+95	1.82	110.60	42.72	18.49	6.27	13.60	7.13	2.15	654.65
15	173+00 to 182+80	2.01	114.51	78.47	19.47	6.60	8.72	9.91	1.85	1,145.77
16	182+80 to 192+00	1.72	106.90	73.41	18.21	6.18	8.05	9.32	1.70	853.67
19	215+28 to 225+10	2.24	173.63	95.17	51.46	18.74	28.85	14.33	9.37	937.57
20	225+10 to 235+50	2.20	186.85	102.27	55.31	20.31	30.65	15.49	10.15	1,264.55
	Total.....	32.56	2,040.48	1,032.00	388.69	129.16	247.77	161.18	50.59	14,417.02

PRICES OF LABOR AND MATERIALS.

The above cost data are based upon the following unit costs for labor and for materials (f. o. b. nearest siding):

Common labor, per day, $1 to $2.
Skilled labor, per day, $2.50 to $3.
Teams, per day, $4 to $4.50.
Foremen, per day, $2 to $2.50.
Carpenters, per day, $2.25 to $4.50.
Rollermen, per month, $65 to $75.
Mixing-plant engineer, per month, $80.
Motor-truck drivers, per month, $100.
Steam shovel engineer, per month, $150.
Foremen, per month, $75 to $150.
Timekeeper, per month, $80.
Superintendent, per month, $150.
Sandstone, all sizes, per ton, $1.37.
Gneiss, 1½-inch, per ton, $1.21.
Gneiss, ¾-inch, per ton, $1.25.
Gneiss chips, per ton, $1.85.
Trap, 1½-inch, per ton, $1.25.
Trap, ¾-inch, per ton, $1.45.
Trap chips, per ton, $1.85.
Granite, all sizes, per ton, $1.43.
Gravel, pit-run, per ton, $0.06⅔.
Gravel, pea, per ton, $1.11.
Asphalt A, per gallon, $0.123 and $0.127.
Asphalt B, per gallon, $0.127.
Asphalt X, per gallon, $0.65.
Asphalt Y, per gallon, $0.059.
Refined tar, per gallon, $0.100.
Cement, per barrel, $1.65.
Washed gravel, per ton, $0.95.
Sand, per ton, $0.83.
Lumber, per thousand, $17 to $26.
Reinforcing steel, per pound, $0.02.
Coal, per ton, $3.75 to $4.25.
Wood, fuel, slabs, per load, $1.
Cast-iron pipe, 10-inch, per foot, $0.75.
Cast-iron pipe, 12-inch, per foot, $0.85 and $0.88.
Cast-iron pipe, 16-inch, per foot, $1.16.
Cast-iron pipe, 18-inch, per foot $1.58.
Corrugated-metal pipe, 15-inch, per foot, $0.66⅔, $0.67, 0.99\frac{9}{10}$, and $1.00.
Corrugated metal pipe, 18-inch, per foot, $0.65, $0.78¼, and $1.15.
Corrugated metal pipe, 24-inch, per foot, $0.93¾ and $1.26.

Additional items of depreciation, repairs, interest, and rental on equipment:

Steam shovel	$735.00
Industrial railway equipment	200.00
Pile driver	50.00
Mixing plant	651.21
Penetration equipment	208.00
Rollers	750.00
Wagons	105.00
Plows, scarifier, hand tools, scales	421.50

Table 23 gives the results of a traffic census taken before and after improvement of the road.

TABLE 23.—*Volume and character of traffic on Mount Vernon Avenue at Mount Ida.*

		Average before improvement.[1]		Average after improvement.[2]	
		North.	South.	North.	South.
1	Loaded 1-horse wagon	8	10	12	12
2	Unloaded 1-horse wagon	3	2	0	0
3	Loaded 2-horse wagon	5	10	4	3
4	Unloaded 2-horse wagon	8	5	1	2
5	Loaded 4-horse wagon	0	0	0	0
6	Unloaded 4-horse wagon	0	0	0	0
7	1-horse pleasure vehicle	6	7	3	3
8	2-horse pleasure vehicle	0	0	0	0
9	Rubber-tired horse vehicle	0	0	0	0
10	Saddle horse	4	2	0	0
11	Motor cycle	3	3	2	2
12	Excessively heavy vehicle	0	0	0	0
13	Motor runabout	0	0	9	9
14	Motor touring car	20	20	83	81
15	Loaded motor dray	3	3	9	6
16	Unloaded motor dray	1	1	0	0

[1] Average of 8 days in March and 7 days in June, 1915. [2] Average of 7 days in December, 1915.

EXPERIMENTS ON FALLS ROAD, MONTGOMERY COUNTY, MD.

SURFACE TREATMENT (OILS, TAR PREPARATIONS, REFINED TARS).

In the summer of 1913 a series of bituminous surface treatments was applied to Rockville Pike in Montgomery County, Md. The original report of these experiments is given in U. S. Department of Agriculture Bulletin No. 105 and a subsequent report of behavior was made in Department Bulletin 257. In order to make it possible to check the data secured from several of these experiments, another series of comparative test sections was constructed on the Falls Road, leading from Rockville to Potomac, Md. In the Falls Road series, sections 1, 2, 4, and 5 were treated with bituminous materials similar to those used on Rockville Pike sections 3, 5, 2, and 1, respectively. The coal-tar preparation selected for Experiment No. 3 on Falls Road had not been used in any previous service tests in this vicinity. Conditions surrounding the two experimental roads are much the same, except that traffic is lighter and the proportion of horse-drawn vehicles greater on the Falls Road.

The specifications prescribed a uniform application of one-half gallon of bituminous material per square yard, but the amount was varied according to the surface condition of the several sections. The road surface was dry when the applications were made, and fine gravel was used to cover the bituminous material. The mechanical analysis of the gravel used is given in Table 24.

The bitumen was transported to the road and spread by means of two 1,200-gallon automobile distributors equipped with speed and pressure gauges. The length of the nozzle-line was so adjusted that one-half of the width of the road was sprayed at one time. The nozzles were of the right-line type, from which the bitumen was applied in a fan-shaped spray under a uniform pressure of approximately 25 pounds.

The Falls Road was reconstructed in 1913, and surfaced with water-bound macadam 15 feet wide. Early in the summer of 1915, when the experimental test sections were planned, the macadam surface had become thoroughly compacted, and, with a few exceptions, was smooth, free from ruts or depressions, and in good condition to receive the bituminous material. In August the contractor distributed all the gravel required for the work with a two-ton motor truck before he began the application of the bituminous materials. The action of this truck was so severe that when the gravel had been distributed, the water bond in sections 1, 2, and part of 3 was completely broken, and several weak places in the foundation in section 2 had formed. The latter were repaired, and an effort was made to reestablish the water bond. Owing to the protracted drought and the disturbing action of traffic, this work was only partially suc-

cessful. The condition of the surface of each section at the time of treatment is discussed in detail in connection with each experiment. The cost of this repair work was $70.

Experiment No. 1 begins at the city limits of Rockville, and the remainder of the series follow in regular numerical order. The details of the work are subjoined.

TABLE 24.—*Mechanical analysis of gravel used on Rockville-Potomac Road.*

	Per cent.
Passing ¾-inch screen, retained on ½-inch screen	9.8
Passing ½-inch screen, retained on ¼-inch screen	62.2
Passing ¼-inch screen, retained on ⅛-inch screen	25.2
Passing ⅛-inch screen	2.8
Total	100.0

EXPERIMENT NO. 1.—ASPHALTIC PETROLEUM, COLD APPLICATION, CORRESPONDING TO EXPERIMENT NO. 3, ON ROCKVILLE PIKE.

Location: Station 0+00 to station 4545+75.
Length: 4,575 feet.
Total area: 7,625 square yards.
Date of application: September 23 and 24.
Temperature of petroleum: About 90° to 100° F.

TABLE 25.—*Analysis of asphaltic petroleum used in Experiment No. 1.*

Specific gravity, 25°/25° C.	0.944
Flash point, ° C.	26
Burning point, ° C.	90
Viscosity, Engler 50 c. c. at 25° C., specific	86.6
Loss, 5 hours at 163° C., 20 grams, per cent	26.54
Float test on residue at 50° C. (time)	2′ 0″
Per cent of total bitumen insoluble in 86° B. naphtha	13.70
Fixed carbon, per cent	7.93
Soluble in CS_2 (total bitumen), per cent	99.94
Organic matter insoluble, per cent	.06
Inorganic matter insoluble, per cent	.00
Total	100.00

Except for a few short sections, the total length of which did not exceed 300 feet, the stone in the surface of Experiment No. 1 was loose and covered with a layer of dust. The surface was swept lightly to avoid displacing the stone, and masses of undesirable matter were removed with hoes and shovels. In order to facilitate the adhesion of the petroleum to the dusty stones, much hand-brooming was required. The oil was permitted to lie for about 2 hours before the gravel was applied. The oil was shipped in a tank car, which was placed about 1 mile from the beginning of the section.

EXPERIMENT NO. 2.—RESIDUAL ASPHALTIC PETROLEUM, HOT APPLICATION, CORRESPONDING TO EXPERIMENT NO. 5, ON ROCKVILLE PIKE.

Location: Station 45+75 to station 89+61.
Length: 4,386 feet.
Total area: 7,310 square yards.
Date of application: September 27 and 28.
Temperature of bitumen: 180° F.

TABLE 26.—*Analysis of residual asphaltic petroleum used on experiment No. 2.*

Specific gravity, 25°/25° C	0.981
Viscosity engler, 100° C, 50 c. c., specific	16.8
Loss, 5 hours, at 163° C., 20 grams, per cent	5.81
Float test on residue at 50° C	2′ 8″
Per cent of total bitumen insoluble in 86° B. naphtha	17.83
Fixed carbon, per cent	10.23
Soluble in CS_2 (total bitumen) per cent	99.93
Organic matter, insoluble, per cent	.07
Inorganic matter, insoluble, per cent	.00
Total	100.00

The condition of the road surface was similar to that in section No. 1, except that the combined total length of areas in which the water bond was unbroken approximated 700 feet. In several places the foundation had failed, and extensive repairs and the digging of drainage ditches were necessary. The petroleum was delivered in a tank car in which it was heated by steam from a traction engine. Owing to the loose condition of the surface, practically three-quarters of a gallon of petroleum were applied per square yard. Much hand brooming of the petroleum was required to cause it to adhere to the dusty stone and produce uniform distribution. About three hours elapsed between spreading the oil and covering it with gravel. About 15 cubic yards of gravel were subsequently required on the firm portions of the road to take up the exuding bitumen.

EXPERIMENT NO. 3.—COAL-TAR PREPARATION, COLD APPLICATION.

Location: Station 89+61 to station 169+02.
Length: 7,941 feet.
Total area: 13,235 square yards.
Date of application: October 11, 12, and 13.
Temperature of preparation: about 90° to 100° F.

TABLE 27.—*Analysis of coal-tar preparation* [1] *used on experiment No. 3.*

Specific gravity, 25°/25° C.	1.144
Viscosity, Engler, 50 c. c. at 40° C., specific	10.4
Free carbon (insoluble in CS_2) per cent	5.53

Distillation:	Per cent by volume.	Per cent by weight.
Water	[2] 1.8	1.6
First light oils (to 110° C)	[3] .7	.4
Second light oils (110° to 170° C.)	[3] 1.0	.6
Heavy oils (170° to 270° C.)	[3] 23.2	20.1
Heavy oils (270° to 315° C.)	[3] 10.2	8.9
Pitch residue	[4] 63.1	68.3
Total	100.0	99.9

All but 500 linear feet of the road surface near the south end of the section was in excellent condition to receive the surface treatment. The section was thoroughly swept with horse-drawn rotary sweepers, and the tar adhered uniformly to the surface rock without the aid of hand brooming. After about 500 linear feet of surface had been sprayed, the distributor was stopped and the gravel was spread immediately to prevent the tar from flowing off the surface over the shoulders. The tar preparation was shipped in a tank car, which was placed 2½ miles from the near end of section 3.

EXPERIMENT NO. 4.—REFINED WATER-GAS TAR, COLD APPLICATION, SIMILAR TO EXPERIMENT NO. 2 ON ROCKVILLE PIKE.

Location: Station 169+02 to station 226+20.
Length: 5,718 feet.
Total area: 9,530 square yards.
Date of application: September 22 and 23.
Temperature of tar: About 130° F.

TABLE 28.—*Analysis or refined water-gas tar used on experiment No. 4.*

Specific gravity, 25°/25° C.	1.132
Viscosity, Engler, 50 c. c. at 50° C., specific	16.2
Free carbon (insoluble in CS_2), per cent	0.64

Distillation:	Per cent by volume.	Per cent by weight.
Water	0.0	0.0
First light oils (to 110° C)	.0	.0
Second light oils (110° to 170° C.)	[2] 1.5	1.0
Heavy oils (170° to 270° C.)	[3] 21.5	18.9
Heavy oils (270° to 315° C.)	[2] 15.0	13.4
Pitch residue	[4] 62.0	66.6
Total	100.0	99.9

The surface of this section was in excellent condition and no repairs were required. The experiment was conducted in all respects like experiment No. 3. The tar when delivered in the distributors from

[1] Thin fluid. [2] Clear. [3] Cloudy. [4] Hard, glossy, semisolid.

the plant was still slightly warm from the refining process. The distance from the plant to the near end of the section was about 12 miles.

EXPERIMENT NO. 5.—REFINED COAL TAR, HOT APPLICATION, SIMILAR TO EXPERIMENT NO. 1, ON ROCKVILLE PIKE.

Location: Station 226+20 to station 295+00.
Length: 5,880 feet.
Total area: 9,800 square yards.
Date of application: September 13, 14, 15, and 16.
Temperature of tar: 180° F.

TABLE 29.—*Analysis of refined coal tar used on experiment No. 5.*

Specific gravity, 25°/25° C.	1.181
Float test at 32° C. (time)	1′ 45″
Free carbon (insoluble in CS_2), per cent	9.39

Distillation:	Per cent by volume.	Per cent by weight.
Water	0.0	0.0
First light oils (to 110° C)	.0	.0
Second light oils (110° to 170° C.)	.0	.0
Heavy oils (170° to 270° C.)	13.5	11.4
Heavy oils (270° to 315° C.)	13.2	11.3
Pitch residue	73.3	77.8
Total	100.0	100.5

The surface of section No. 5 was also in excellent condition, and the experiment was conducted similarly to experiments Nos. 3 and 4. The bitumen was prepared in a local plant and was hauled to the work in the distributors ready for application. The haul from the plant to the near end of the section was about 11 miles.

The cost data given in Table 30 are based upon the following unit prices for labor and materials.

Foreman, per 8-hour day	$4.00
Distributor operator, per 8-hour day	2.50
Roller operator, per 8-hour day	3.00
Motor-truck driver, per 8-hour day	2.50
Teams, per 8-hour day	4.00
Laborers, per 8-hour day	1.60–2.00
Gravel on siding, per ton	1.65
Asphaltic petroleum on siding, per gallon	[1].05
Residual asphaltic petroleum on siding, per gallon	[1].07½
Coal-tar preparation on siding, per gallon	[1].09½
Refined water-gas tar at plant, per gallon	[1].08½
Refined coal tar at plant, per gallon	[1].08

[1] Estimated.

TABLE 30.—*Materials and cost data for surface-treatment experiments on Falls Road.*

Experiment No.	Corresponding to Rockville Pike Experiment No.	Description.			Quantity of materials (per square yard).		Cost per square yard.	
		Bituminous material.	Length of section.	Area of section.	Bituminous material.	Gravel.[1]	Bituminous material.	Gravel (hauling included).
			Feet.	*Sq. yds.*	*Gallon.*	*Cu. yds.*	*Cents.*	*Cents.*
1	3	Asphalt petroleum (cold)	4,575	7,625	0.525	0.0149	2.63	3.84
2	5	Residual asphaltic petroleum (hot)	4,386	7,310	.739	.0164	5.54	4.25
3	.....	Coal-tar preparation (cold)	7,941	13,235	.423	.0151	4.02	3.53
4	2	Refined water-gas tar (cold)	5,718	9,530	.538	.0150	4.57	3.67
5	1	Refined coal tar (hot)	5,880	9,800	.596	.0150	4.77	3.65

Experiment No.	Description.	Cost per square yard.						Total cost.	
	Bituminous material.	Cleaning surface.	Heating bituminous material.	Hauling and applying hot material.[2]	Spreading gravel.	Rolling.	Miscellaneous.[3]	Per square yard.	Per mile, 15-foot road.
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	
1	Asphaltic petroleum (cold)	0.05	.....	0.23	0.32	0.05	0.65	7.77	$683.76
2	Residual asphaltic petroleum (hot)	.05	0.41	.37	.71	.10	.68	12.11	1,065.68
3	Coal-tar preparation (cold)	.01	.....	.12	.38	.04	.38	8.48	746.24
4	Refined water-gas tar (cold)	.04	.....	.24	.55	.04	.52	9.63	847.44
5	Refined coal tar (hot)	.08	.....	.32	.86	.02	.51	10.21	898.48

[1] 2,500 pounds equals 1 cubic yard.
[2] Hauled to road in distributor.
[3] General expense and superintendent.

INSPECTION REPORT.

The following report describes the condition of the experiments on the Falls Road on the date of last inspection, April 27, 1916.

Experiment No. 1.—At the time of the inspection the surface did not appear to carry a distinct mat or carpet and the bituminous treatment was worn very thin and showed a tendency to crumble, even on warm days. It is probable that a re-treatment will be necessary early in the spring as the aggregate of the macadam shows quite generally throughout the central portion of the road.

Experiment No. 2.—This section has a black, leathery mat which is easily marked by the calks of passing horses, but irons out under the wheels so that there is no indication of "picking up" or disintegration. In a few places additional gravel had to be spread to prevent bleeding, and it is probable that more top-dressing will be required as soon as hot weather prevails. At the present time very little stone shows in the mat.

Experiment No. 3.—The gravel used for top-dressing plainly shows everywhere on this section and an excess still remains along the sides. The mat is a hard, stone-filled carpet, practically unbroken, and shows no signs of failure anywhere. In general this was the best appearing section of the road at the time of the inspection.

Experiment No. 4.—The appearance of this section is similar to that of experiment No. 3, but the mat is thinner and the limestone aggregate of the macadam is slightly but quite uniformly visible over the entire section along the central portion of the road. Some excess top-dressing still remains along the shoulders. It is probable that the section will require re-treatment in the spring.

Experiment No. 5.—The mat on this section is softer than that on sections 3 and 4, but much less leathery than that on section 2. The macadam shows through in a few places, but the mat is not broken at any point. It is probable that this section will require a re-treatment late in the summer or fall. About 300 feet from the south end of the section there is an area about 20 feet in length and extending nearly the entire width of the road, where the surface was rather badly burned as the result of the burning of a blacksmith shop and stables near the road.

EXPERIMENTS ON BRADLEY LANE, MONTGOMERY COUNTY, MD.

BITUMINOUS MACADAM (PENETRATION METHOD).

The experiments previously reported for this road have been discontinued because the design was considered inadequate for the prevailing traffic. The traveled way was only 10 to 12 feet wide, while the road carried practically as heavy traffic as the adjacent section of the Rockville Pike. Partly also because of the exceedingly poor drainage and foundation conditions, it had never been possible to maintain the surface satisfactorily, and it had become rutted and was continually breaking into potholes, while the edges were badly cut and sheared by traffic. Finally, in June, 1915, arrangements were made to reconstruct the roadway as a new experiment, and a bituminous macadam surface, constructed according to the penetration method, was the type of improvement adopted.

The old surface-treated macadam was scarified, reshaped, and widened by the addition of new material to form the foundation course for the new surface. The total length of the road is 3,813.5 feet. The width of the new roadway was made 16½ feet from Connecticut Avenue westward for approximately 2,404 feet by adding 2½ feet to the south side and 4 feet to the north side of the old surface; the remaining distance to Wisconsin Avenue was made 15 feet wide by adding 2½ feet to each side of the old surface. In preparing the foundation course it was necessary to add 145 tons of new limestone; and in order to increase the stability of the foundation, 3,646 linear feet of 4-inch drain tile was used. The drain tile was placed under the south gutter of the road at a depth of a foot or more below the surface, and is expected to correct the unsatisfactory foundation condition referred to in the preceding paragraph. The drainage was further improved by cleaning out all existing culverts and

paving culvert inlets and outlets with gneiss spalls where this was necessary. Two existing catch basins which were considered too small for the service demanded of them were reconstructed and enlarged and two new catch basins were constructed at other points.

After the foundation course was thoroughly compacted by rolling, an entirely new wearing surface was constructed. The wearing surface consists of a 3-inch depth of fresh limestone (loose measurement) bonded together with bituminous material. The same bituminous material was used throughout, but two different methods were employed. From station 0+00 to station 19+00 and from station 21+00 to station 38+13½ straight oil-asphalt was used, while for the remaining 200 feet between stations 19 and 21 a sand-oil-asphalt grout was used.

THE OIL-ASPHALT SECTION (PENETRATION METHOD).

Location: Station 0+00 to station 19+00 and station 21+00 to station 38+13½.
Area: 6,421 square yards.

These sections comprise a total area of 6,421 square yards and were constructed in accordance with the common penetration method; that is, the penetration course of stone was spread and rolled, bitumen applied, screenings spread, and the surface finished with a seal coat of bitumen and stone chips.

One and a half gallons of bitumen per square yard was used in the penetration course and approximately one-half gallon per square yard in the seal coat. A total of 7,150 gallons of bitumen was used on the first section and 6,328 gallons on the second section, which gives a total average quantity per square yard of 2.012 gallons and 2.16 gallons, respectively, for the two sections. Table 31 shows the analysis of the oil-asphalt used, and Table 32 the cost of the work, which was done by contract.

TABLE 31.—*Analysis of oil-asphalt.*[1]

Specific gravity 25°/25° C.	1.024
Melting point °C.	50
Penetration 25° C., 100 grams, 5 seconds	105
Loss 5 hours at 163° C., 20 grams, per cent	.19
Penetration of residue[1] as above	64
Percentage of total bitumen insoluble in 80° naphtha	25.77
Fixed carbon, per cent	15.74
Soluble in CS_2 (total bitumen), per cent	99.70
Organic matter insoluble, per cent	.18
Inorganic matter insoluble, per cent	.12
Total, per cent	100.00

[1] Fairly hard, glossy, sticky, semisolid.

TABLE 32.—*Unit and total costs.*

Items.	Unit cost.	Total cost.
Clearing and grubbing, lump sum		$79.61
Excavation, 793 cubic yards	$0.4704	373.03
Subdrains, 3,646 feet 4-inch tile	.2145	782.07
Scarifying, 5,316 square yards	.0304	161.61
Shaping shoulders and subgrade, 4,064 square yards	.0371	150.87
Foundation stone, 146,775 tons in place	2.196	322.32
Wearing course, penetration method, 6,421 square yards	.3284	2,108.66
Wearing course, sand-oil grout, 367 square yards	.3942	144.66
Total		4,122.83

SAND-OIL GROUT (PENETRATION METHOD).

Location: Station 19+00 to station 21+00.
Area: 366.7 square yards.

This section includes two experiments in the use of oil asphalt mixed with sand for constructing a bituminous macadam surface according to the penetration method. The first experiment extends from station 19+00 to station 19+55, and was constructed in a manner exactly similar to that described above for the straight penetration work, except that 50 per cent by volume of sand was used with the bituminous material. The second experiment extends from station 19+55 to station 21+00 and was constructed in a similar manner to the preceding, except that only 33 per cent by volume of sand was used with the bituminous material.

A total of 672 gallons of oil asphalt were used in the two experiments, which is at the rate of about 1.83 gallons per square yard. It appears, therefore, that the saving in bituminous material which was effected by employing this method is only about 0.2 gallon per square yard; and if the cost of heating the sand and mixing the oil-sand grout is considered, the cost was greater with this method than with the ordinary penetration method by about 2 cents per square yard. It is very questionable, therefore, if the experiment will prove of value. It will be kept under close observation, however, with a view to ascertaining any possible superiority which this section may possess over the ordinary penetration sections.

EXPERIMENTS AT WASHINGTON, D. C.

BITUMINOUS CONCRETE.

The bituminous concrete experiments at Washington, D. C., consisted in the construction of two wing drives leading from the sheet-asphalt pavement in front of the main building of the United States Department of Agriculture to the sheet-asphalt plaza in the rear, and was completed on December 7, 1915. Each of the drives is approximately 140 feet long and 18 feet wide. The type of construction was bituminous concrete upon a 6-inch foundation of Portland cement

concrete. Sand and gravel of the mechanical analyses given in Tables 33 and 34 were used in the concrete, which was mixed in a mechanical mixer and allowed to stand 10 days before the wearing surface was applied. The proportion of the mix, by volume, was 1 part cement, 3 parts sand, 7 parts gravel.

Two types of bituminous concrete were chosen for the wearing course, which was spread so as to compact to a thickness of 2 inches. The northern half of each drive was surfaced with a mixture prepared according to the Topeka specification, while the southern half of each was paved with bituminous concrete prepared according to the District of Columbia specification. The analyses of the bituminous aggregates of these preparations are given in Table 35 and Table 36, respectively. An analysis of the oil-asphalt is given in Table 37.

The bituminous concrete was prepared in a local plant and was delivered to the site of the work in trucks at a temperature of 220° F. or more. After being spread and sufficiently cooled the mixture was given a preliminary rolling with a 3-ton tandem roller and was finished with a 12-ton roller. A seal coat of oil-asphalt represented by the analysis given in Table 37 was spread with a squeegee on the areas surfaced with the District of Columbia mixture, and covered with hot stone chips immediately. In the case of the Topeka mixture the seal coat was omitted and the surface was dusted lightly with Portland cement.

TABLE 33.—*Mechanical analysis of sand used in concrete base.*

	Per cent.
Total retained on 10-mesh sieve	10.2
Total retained on 20-mesh sieve	33.9
Total retained on 30-mesh sieve	53.9
Total retained on 40-mesh sieve	66.4
Total retained on 50-mesh sieve	77.9
Total retained on 80-mesh sieve	95.9
Total retained on 100-mesh sieve	96.5
Total retained on 200-mesh sieve	97.9
Passing 200-mesh sieve	2.0

TABLE 34.—*Mechanical analysis of gravel used in concrete base.*

	Per cent.
Total retained on 1¼-inch screen	2.1
Total retained on 1-inch screen	5.5
Total retained on ¾-inch screen	18.1
Total retained on ½-inch screen	34.7
Total retained on ¼-inch screen	70.7
Total retained on 10-mesh sieve	94.0
Passing 10-mesh sieve	6.0

TABLE 35.—*Analysis of bituminous concrete (Topeka specification).*

	Per cent.
Bitumen soluble in CS_2	8.25
Mineral aggregate:	
Passing ½-inch screen, retained on ¼-inch screen	7.9
Passing ¼-inch screen, retained on 10-mesh sieve	17.2
Passing 10-mesh sieve, retained on 20-mesh sieve	17.3
Passing 20-mesh sieve, retained on 30-mesh sieve	9.8
Passing 30-mesh sieve, retained on 40-mesh sieve	9.3
Passing 40-mesh sieve, retained on 50-mesh sieve	10.2
Passing 50-mesh sieve, retained on 80-mesh sieve	14.2
Passing 80-mesh sieve, retained on 100-mesh sieve	2.7
Passing 100-mesh sieve, retained on 200-mesh sieve	7.5
Passing 200-mesh sieve	3.9
Total	100.0

TABLE 36.—*Analysis of bituminous concrete (District of Columbia specification).*

	Per cent.
Bitumen soluble in CS_2	7.2
Mineral aggregate:	
Passing 1-inch screen, retained on ¾-inch screen	6.8
Passing ¾-inch screen, retained on ½-inch screen	14.4
Passing ½-inch screen, retained on ¼-inch screen	24.3
Passing ¼-inch screen, retained on 10-mesh sieve	14.0
Passing 10-mesh sieve, retained on 20-mesh sieve	7.5
Passing 20-mesh sieve, retained on 30-mesh sieve	6.1
Passing 30-mesh sieve, retained on 40-mesh sieve	6.4
Passing 40-mesh sieve, retained on 50-mesh sieve	6.2
Passing 50-mesh sieve, retained on 80-mesh sieve	4.4
Passing 80-mesh sieve, retained on 100-mesh sieve	1.1
Passing 100-mesh sieve, retained on 200-mesh sieve	4.4
Passing 200-mesh sieve	4.4
Total	100.0

TABLE 37.—*Analyses of oil asphalts used in experiments at Washington, D. C.*

Use.	Bituminous concrete.	Seal coat.
Specific gravity 25°/25° C.	1.055	1.055
Melting point, ° C.	55	58.5
Penetration at 25° C., 100 grams, 5 seconds	63	47
Loss, 5 hours at 163° C., 20 grams, per cent	.56	.31
Penetration of residue, as above	40	34
Per cent of total bitumen insoluble in 86° C. naphtha	26.40	31.76
Fixed carbon, per cent	19.32	19.33
Soluble in CS_2 (total bitumen), per cent	98.39	99.88
Organic matter insoluble, per cent	.70	.11
Inorganic matter insoluble, per cent	.91	.01
Total, per cent	100.00	100.00

The cost data given in Table 38 is based on unit costs of labor and material as follows, and represents approximately the contractor's cost:

Labor:	
1 foreman, per day	$4.00
1 foreman, per day	2.50
Laborers, per hour	0.20–0.40
Teams, per hour	.60
Materials on road:	
Cement, per barrel	1.32
Sand for concrete, per ton	.55
Gravel for concrete, per ton	.65
Bituminous concrete on road (estimated), per square yard	.40
Oil asphalt for seal coat, per gallon	.10
Stone chips for seal coat, per ton	1.00

TABLE 38.—*Materials and cost data for bituminous-concrete experiments at Washington, D. C.*

General.	Detail.	District of Columbia specification.	Topeka specification.
Materials for base, per square yard of pavement	Cement, barrel	0.115	0.115
	Sand, ton	.075	.075
	Gravel, ton	.165	.165
Materials for surface, per square yard of pavement	Bituminous concrete	[1]	[1]
	Bituminous seal coat, gallons.	.30	.....
	Cement used on surface, barrels.	.....	.003
	Stone chips for seal coat, tons	.015	.....
Costs for base per square yard of pavement, in cents	Prepared subgrade	20.88	20.88
	Cement	15.16	15.16
	Sand	4.09	4.09
	Gravel	10.70	10.70
	Header strips in place	4.43	4.43
	Mixing and laying concrete	10.08	10.08
Costs for surface per square yard of pavement, in cents.	Bituminous concrete on road	40.00	40.00
	Spreading	8.90	8.90
	Rolling	.90	.90
	Bituminous seal coat	3.00	.....
	Chips for seal coat	1.50	.....
	Applying seal coat	1.40	.....
	Cement on surface	.....	.40
Total		121.04	115.54

[1] Not determined.

EXPERIMENTS AT BUENA VISTA, FLA.

RESIDUAL ASPHALTIC PETROLEUM-CORALLINE ROCK.

As a result of observation of the behavior of the various experimental sections built on Biscayne Drive at Miami in 1913, and reported in Department Bulletin No. 105, it was decided to construct another section similar in all respects to section No. 6, except that a heavier asphaltic material, better suited for use with coralline rock, was to be employed.

The work was done on the driveway leading from the Miami-Lemon City Road into the grounds of the experimental gardens of the United

States Department of Agriculture, located about 3 miles north of Miami. The roadway is 1,725 feet long and is 12 feet and 16 feet in width. The traffic to which it is subjected is light, and originates on the grounds of the experimental gardens.

The site is a new location, which was cleared, grubbed, and graded immediately before the surfacing was undertaken. After leaving the Miami-Lemon City Road, the first 600 feet was a deep sand bed, while the remainder was a succession of ridges of coralline rock, with sand beds intervening. The coralline ridges were excavated, and a uniform sand subgrade was prepared.

The surfacing materials used were coralline rock and a heavy asphaltic oil. The properties of the rock as it occurs near Miami are noted in U. S. Department of Agriculture Bulletin No. 105. The subgrade, which was 6 inches thick, loose, was built of coralline fieldstone gathered on or near the site of the project, sledged on the subgrade and thoroughly rolled.

The rock for the wearing course was taken from a county pit about 1 mile from the road. The fine material resulting from blasting was eliminated by screening the rock over one-fourth inch stationary screens. The wearing course was 3 inches thick, loose, and was rolled once over with an 8-ton macadam roller before the bituminous material was applied. The cross section of the road shows a crown slightly less than one-half inch per foot.

The properties of the bituminous material are stated in Table 39. This material was delivered in barrels, heated in 1-barrel kettles, and applied by means of hand-pouring pots. From 1 to 3 hours after it had been poured the bituminous material was covered with about one-half inch of sand which had been taken from the roadside and screened to remove twigs, roots, etc. The sanded surface was then rolled until all visible movement of the surface particles ceased, after which the road was opened to traffic.

The cost of the various processes involved in the construction of this section are given in Table 40. The cost data are based on labor and material as follows:

Superintendent, per day	$4.00
Foreman, per day	3.00
Teams, per day	5.00
Labor, per day	1.50
Roller, per day	6.00
Bitumen, per gallon	.134

TABLE 39.—*Analysis of residual asphaltic petroleum used at Buena Vista, Fla.*

Specific gravity 25°/25° C.	0.992
Viscosity, Engler, 50 c. c. at 100° C. specific	31.5
Float test at 32° C., time	2′ 44″
Float test at 50° C., time	1′ 04″
Loss at 163° C. 5 hours, 20 grams, per cent	.75
Float test of residue at 50° C., time	1′ 30″
Per cent of total bitumen insoluble in 86° B. naphtha	13.02
Fixed carbon, per cent	8.20
Soluble in CS_2 (total bitumen), per cent	99.91
Organic matter insoluble, per cent	.09
Inorganic matter insoluble, per cent	.00
Total, per cent	100.00

TABLE 40.—*Cost data on construction of coralline-rock road.*

Materials used:	
No. 2 stone, cubic yard per square yard	0.083
Sand, cubic yard per square yard	.014
Bitumen, gallon per square yard	.906
Cost per square yard:	
No. 2 stone	$0.1546
Bitumen	.1243
Spreading No. 2 stone	.0175
Heating and applying bitumen	.0075
Spreading sand	.0105
Rolling	.0079
General expense	.0186
Total	.3409
Total costs for surface:	
Quarrying and crushing No. 2 stone, 227 cubic yards	302.85
Loading and hauling No. 2 stone to road	118.00
Spreading No. 2 stone	47.50
Bitumen on siding, 2,465 gallons	330.31
Unloading and hauling bitumen to road	8.00
Heating and applying bitumen	20.40
Spreading sand, 38 cubic yards	28.75
Rolling	21.60
General expense	50.60
Total	928.01
Cost of preliminary work:	
Grading	132.11
Shaping subgrade, 2,722 square yards	51.65
Gathering and hauling foundation stone, 454 cubic yards	125.90
Spreading and sledging foundation stone	95.00
Rolling foundation stone	10.80
Total	415.46

This pavement was completed in May, 1915. When inspected in December, 1915, it showed no evidence of failure or appreciable wear. The normal amount of traffic to which the road will be subjected is not yet developed, and another year will be required to test the wearing qualities of this pavement.

EXPERIMENTS AT JUPITER, PALM BEACH COUNTY, FLA.

OIL-ASPHALT-SAND.

The purpose of this experiment was to demonstrate a simple and inexpensive method of treating the deep sand roads of Florida which are subjected to light traffic. The demonstration section is on West Lateral Road, 1.8 miles north of Jupiter, Fla. The bitumenized portion is 152 feet long and 9 feet wide, skirted on both sides by untreated sand shoulders 5½ feet wide.

The mineral aggregate used was the native sand found in and along the roadway, in which was incorporated asphaltic materials, the properties of which are given in Table 41. The sandbed was prepared for treatment by removing with hand rakes all twigs, sod, and similar undesirable matter from a width 10 feet on each side of the center line of the road. The sand in this area was then smoothed down to a uniform grade, while the cross section was shaped to a total crown of about 5 inches over the 20-foot width.

The bituminous material was heated in 1-barrel kettles and was spread by means of hand-pouring pots in a series of applications, according to what is commonly known as the layer method. Four such applications were made. Each was covered with a layer of sand after the bituminous material had been partly absorbed. The sand for this purpose was obtained from the shoulders. Each layer of sand was thoroughly rolled with a 3-ton horse roller before the succeeding application of bitumen was made. The quantity of bituminous material and the thickness of the sand cushions in the various layers are stated below:

(1) One-third gallon of bitumen A per square yard, over which was spread one-half inch of sand; (2) two-thirds gallon of bituminous material A per square yard which was covered with 1 inch of sand; (3) two-thirds gallon of bituminous material A per square yard, followed by a layer of 1 inch of sand; (4) one-third gallon of a combination of equal parts of A and B per square yard, to which was applied enough sand to absorb the bituminous material.

The resulting cushion of bitumenized sand is approximately 3 inches thick. The original plan involved the use of three layers only, but because of the damp condition of the sand on which the first application of oil was made, the hot asphalt foamed freely and the quantity poured was reduced by one-half. It was necessary, therefore, to add another thin layer to give the desired depth.

After the surface covering of sand was spread, the shoulders and ditches were reshaped and the road was opened to traffic. A few days later the asphalt began to bleed freely, and the local road official in charge covered the road surface with a heavy additional layer of sand to absorb the exudation.

The road was built on April 9 and 10, 1915, and was inspected December 10, 1915. The surface had received practically no attention since the time of its completion. Along the center line or crown of the 9-foot surface the horses had worn a path from 1 to 2 inches deep and about 14 inches wide, and two corresponding wheel ruts extended the full length of the section. The path and ruts are largely in a mass of loose sand, slightly impregnated with bituminous material from 1 to 1½ inches deep which overlies a firm, hard course of bituminized sand. It is evident that the bituminous material used in the fourth layer was of too viscous a nature to assimilate the sand, or was insufficient in quantity to bind the heavy layer of sand which was spread to absorb the bleeding. Outside of the central traveled portion the surface is less broken.

The surface requires reshaping and a light application of material A to bituminize the loose sand thoroughly. The road will then be scarred and rutted by traffic for several months, after which it should be reshaped with a grader occasionally until it is finally compacted.

TABLE 41.—*Analyses of bituminous materials used in experiment at Jupiter, Fla., 1915.*

	Material.	
	A. Residual asphaltic petroleum.	B. Fluxed native asphalt.
Specific gravity, 25°/25° C	1.01	1.066
Melting point, ° C	.....	59
Viscosity, Engler, 50 CC. at 100° C. specific	63.9	.....
Float test at 50° C. (time)	2′ 5″	.....
Penetration at 25° C. 100 grams, 5 seconds	.....	48
Loss at 163° C. 5 hours, 20 grams, per cent	1.82	3.43
Float test of residue at 50° C. (time)	3′ 34″	.....
Penetration of residue as above	.....	18
Per cent of total bitumen insoluble in 86° B. naphtha	21.22	23.61
Fixed carbon, per cent	12.61	12.02
Soluble in CS_2 (total bitumen), per cent	99.88	95.48
Organic matter insoluble, per cent	.12	1.77
Inorganic matter insoluble, per cent	.....	2.75
Total, per cent	100.00	100.00

COST DATA.

This experiment was of too small extent for the cost data to be of material value. The asphalt was donated, and the total labor cost was only about $12.41, including the grading. This is at the rate of about 8.2 cents per square yard, exclusive of the bituminous material.

Since the work was done with convicts and the conditions were favorable, the cost is probably considerably lower than it would have been under ordinary conditions.

EXPERIMENT AT WEST PALM BEACH, FLA.

In May, 1914, a series of seven experimental sections involving the use of coralline rock and bituminous materials was constructed on the Miami-Quebec Highway, about 2 miles south of West Palm Beach. The details of construction are given in U. S. Department of Agriculture Bulletin No. 257. In order to determine the wearing qualities of a sand-asphalt or bituminous-sand surface in comparison with the seven experimental surfaces, a section of this material was added to the series in January, 1915. It is continuous with the other experiments and adjoins section 7.

Experiment No. 8.—Bituminous Sand Mixing Method.

The original coralline rock road was scarified and reshaped for the foundation. The cross section of the foundation was parallel to the finished surface and 2 inches below it. During the time which elapsed between the preparation of the foundation and the laying of the wearing course, the former was thoroughly compacted by traffic and had become slightly dusty.

In order to secure a sand which was fairly well graded, it was necessary to mix two sands in approximately equal proportions. This was done while they were being screened to remove twigs and other undesirable matter. The mechanical analyses of the original sands and the graded combination are given in Table 42, and the analysis of the fluxed native asphalt, B, is the same as given in Table 41.

The bituminous sand was prepared by mixing heated sand and asphalt on a mixing board with rakes and shovels. A heater having about 90 square feet of heating surface was improvised to bring the temperature of the sand up to from 350° F. to 400° F. and two 1-barrel asphalt kettles were used to heat the bitumen to 300° F.

Beginning at the south end of the section for the first 52 linear feet the sand and asphalt are mixed in the proportions of 10 cubic feet of sand to 10 gallons of asphalt; in the next 27 linear feet the proportions are 10 cubic feet of sand to 11 gallons of asphalt; and in the remaining 3 linear feet the surface consists of a mixture of 10 cubic feet of sand No. 1 to 11 gallons of asphalt. The sand-asphalt mixture was spread 2½ inches thick and was held in place with 2 by 4 inch timber while it was being rolled with a 6-ton tandem roller.

The work was interrupted by a succession of showers. The section was so short that an organization of competent labor could not be perfected and the equipment was of the crudest kind.

The cost of constructing this section was disproportionately high and can not be fairly compared with that of producing the other sections of the series. Neither is it a just criterion of the cost of building a sand-asphalt pavement. Hence the cost data are not given.

TABLE 42.—*Mechanical analyses of sands used in experiment No. 8, West Palm Beach, Fla.*

	No. 1.	No. 2.	Mixed.
	Per cent.	*Per cent.*	*Per cent.*
Retained on 10-mesh sieve	0.0	0.1	0.1
Retained on 20-mesh sieve	.3	.4	.2
Retained on 30-mesh sieve	4.2	1.2	2.3
Retained on 40-mesh sieve	23.9	3.5	11.4
Retained on 50-mesh sieve	31.2	5.2	16.1
Retained on 80-mesh sieve	36.9	36.9	36.4
Retained on 100-mesh sieve	2.4	21.5	15.4
Retained on 200-mesh sieve	1.0	29.5	17.2
Passing 200-mesh sieve	.1	1.6	.6
Total	100.0	100.0	100.0

COST DATA.

This pavement was inspected in December, 1915. It had grown slightly wavy under traffic, but had not failed in any other respect. No difference in behavior or surface appearance was noticeable in the three subdivisions of the section.

EXPERIMENTS AT OCALA, FLA.

OIL-LIMESTONE, SAND-ASPHALT.

Among the road materials locally available in Marion County are sand-clay, a fairly well-graded sand, and easily crumbled oolitic limestone, which hardens somewhat on exposure to the air. It is apparently similar in character to but much softer than the coralline rock used in the Miami and West Palm Beach experiments. In 1915 an object-lesson road was constructed of sand-clay near Ocala, and on completion of this it was decided to construct experimental sections adjacent to the sand-clay road, utilizing the limestone and sand with bituminous materials. The series was installed in the spring of 1915 on the Ocala-Blichton road, about 3½ miles west of Ocala. Limestone for the oil-limestone experiment was obtained from a deposit which outcropped about 1 mile from the road. It was quarried with the use of dynamite and heavy sledges and in this way was easily broken to the desired size. For the surface course of the oil-limestone experiment the limestone was screened at the quarry over a ½-inch screen, yielding approximately 50 per cent retained on a ½-inch screen and passing a 3-inch screen. A suitable quality of sand for the sand-asphalt experiment was located about two-fifths of a mile from the road.

The equipment consisted of 2 sirup-heating kettles of 200 and 80 gallons capacity, which were set in a stone furnace and heated

with wood fuel; a concrete mixer equipped with revolving blades and operated by a 4-horsepower gasoline motor; dump wagons; a 6-ton steam tandem roller; 2 hand rollers; corrugated culvert pipe for heating sand; hand pouring pots; and hand tools.

EXPERIMENT NO. 1.—LIMESTONE, RESIDUAL ASPHALTIC PETROLEUM, PENETRATION METHOD.

Location: Station 201+15 to station 212+92.
Length: 1,177 feet.
Area: 1,834 square yards.

Details.—Upon the rolled subgrade, partly of sand-clay and partly of sand, a foundation course of pit-run limestone was spread and rolled until firm. The depth of the foundation course was 5 inches, loose measurement. Upon this a wearing course, 2 inches thick by loose measurement of screened rock was spread and rolled with the 6-ton tandem roller sufficiently to smooth and shape the course but not to break up the fragments. Upon the wearing course was applied approximately 1 gallon per square yard of the residual asphaltic petroleum, analysis of which is given in Table 43. The petroleum was heated in the large sirup kettle at the roadside and was spread by means of hand-pouring pots. In applying the hot oil care was taken to coat the rock as uniformly and completely as was possible. The oil was immediately covered with sand and the surface was then rolled until firm. As the oil was forced upward through the sand by rolling, more sand was distributed to absorb it. Shoulders, 2 feet wide and 6 inches thick, of pit-run rock or screenings, were constructed on each side of the 14-foot oil-treated road. Materials and cost data for this experiment are given in Table 46.

TABLE 43.—*Analysis of residual asphaltic petroleum used in experiment No. 1.*

Specific gravity 25°/25° C.	0.985
Viscosity, Engler, 100° C., 50 cc., specific	15.6
Float test at 32° C. (time)	1′ 48″
Float test at 50° C. (time)	0′ 40″
Loss, 163° C., 5 hours, 20 grams, per cent	1.64
Float test of residue[1] at 32° C. (time)	6′ 30″
Float test of residue at 50° C. (time)	1′ 30″
Per cent of total bitumen insoluble in 86° B. naphtha	17.98
Fixed carbon, per cent	10.04
Soluble in CS_2 (total bitumen), per cent	99.93
Organic matter insoluble, per cent	.07
Inorganic matter insoluble, per cent	.00
Total, per cent	100.00

[1] Very viscous, sticky fluid.

EXPERIMENT NO. 2.—SAND-OIL ASPHALT.

Location: Station 212+92 to station 220+85.
Length: 793 feet.
Area: 1,233.56 square yards.

Details.—The subgrade on the east end of this experiment, from station 212+92 to station 217+30, was an old sand-clay road, and in general provided a firm foundation. On this section the subgrade was dressed and rolled and the sand-asphalt mixture laid 2½ inches thick after compression. The subgrade from station 217+30 to station 220+85 consisted of fine sand, and the wearing course in this section is 3½ inches thick, laid in one course from station 217+30 to station 219+00, and in two courses, each roughly 1¾ inches thick from station 219+00 to station 220+85. Difficulty in securing a satisfactory bond between the two courses was experienced, owing to the fine sand distributed over the surface by laborers who walked over the first course. The sand subgrade was rolled with the 6-ton tandem roller, but as this left it much rougher than desired it was smoothed with hand rollers immediately in advance of spreading the mixture.

The heating and mixing operations were carried on about two-fifths of a mile from the road, where a clean, well-graded sand was found in abundance. All the sand was screened to remove twigs and roots, and also to reduce it to a finely divided condition, which undoubtedly facilitated heating. It was piled over 15-inch corrugated culvert pipes for heating, and stirred occasionally. This method of heating was found to be costly and relatively inefficient, and lack of heated sand limited the daily output of the mixer to much less than half of its normal capacity. The mixer, which was provided with revolving blades, was operated by a 4-horsepower gasoline motor, and was placed on an elevated platform, so that it could be emptied directly into a chute above the wagons. For each batch 6 cubic feet of heated sand was carried from the heating pipes to the charging platform in wheelbarrows, each carrying 2 cubic feet. After stirring the sand to avoid local overheating, oil-asphalt represented by the analysis given in Table 44 was added in an amount equal to about 10 per cent of the total weight, and the mixing was continued until all particles were thoroughly and uniformly coated with bitumen. The hot mixture was hauled to the road and, from dumping boards laid on the shoulder, was spread with shovels and hot rakes to the required thickness. The forms consisted of timbers placed along each side of the road at the proper grade. As soon as spread, the mix was rolled longitudinally and transversely with hand rollers, and after standing for some time, was covered with a light application of Portland cement, and rolled with the 6-ton tandem roller. The

timbers were then removed and limestone shoulders, 6 inches thick and 2 feet wide, compacted by rolling, were constructed to support the sand-asphalt surface. Table 45 gives typical analyses of the sand-asphalt mixture. The data relating to materials and cost, given in Table 47, do not differentiate between the various sections, but are presented just as if the cost were uniform over the entire experiment, irrespective of the varying thickness of the wearing surface.

TABLE 44.—*Analysis of oil-asphalt* [1] *used in experiment No. 2.*

Specific gravity 25°/25° C.	1.041
Melting point ° C.	64
Penetration, 25° C., 100 grams, 5 seconds	50
Loss, 5 hours, 163° C., 20 grams, per cent	0.06
Penetration of residue [1] as above	38
Per cent of total bitumen insoluble in 86° B. naphtha	29.45
Fixed carbon, per cent	17.50
Soluble in CS_2 (total bitumen), per cent	99.86
Organic matter insoluble, per cent	.10
Inorganic matter insoluble, per cent	.04
Total, per cent	100.00

[1] Hard, sticky, glossy, semisolid.

TABLE 45.—*Typical analyses of sand-asphalt mixtures used in experiment No. 2.*

	I.	II.	III.	IV.	V.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Bitumen (soluble in CS_2)	8.41	8.27	9.87	8.16	10.28
Mineral aggregate:					
Retained on 10-mesh sieve	0.1	0.0	0.1	0.0	0.1
Passing 10-mesh sieve, retained on 20-mesh sieve.	1.6	2.5	1.4	1.1	1.5
Passing 20-mesh sieve, retained on 30-mesh sieve.	4.9	4.7	5.1	4.7	4.3
Passing 30-mesh sieve, retained on 40-mesh sieve.	10.8	10.4	10.9	9.4	7.1
Passing 40-mesh sieve, retained on 50-mesh sieve.	13.1	12.3	13.5	13.7	16.0
Passing 50-mesh sieve, retained on 80-mesh sieve.	31.7	32.3	33.3	33.0	33.4
Passing 80-mesh sieve, retained on 100-mesh sieve.	12.9	11.8	12.5	12.1	12.4
Passing 100-mesh sieve, retained on 200-mesh sieve	15.7	19.7	14.2	12.0	18.4
Passing 200-mesh sieve	9.2	7.2	9.0	14.0	6.9
Average percentage of bitumen (soluble in CS_2)		9.25			

The cost data given in Tables 46 and 47 are based on the following scale of wages and unit prices:

Foreman, per 10-hour day, $3.25.
Subforeman, per 10-hour day, $1.25.
Skilled labor, per 10-hour day, $1.75.
Common labor, per 10-hour day, $1.
Teams, per 10-hour day, $3.
Asphaltic oil, f. o. b. Baltimore, Md., per gallon, $0.06.
Oil-asphalt, f. o. b. Baltimore, Md., per ton, $12.50.
Freight on oil-asphalt, Baltimore, Md., to Ocala, Fla., per ton, $6.72.

TABLE 46.—*Cost data, bituminous limestone.*

Item.	Total cost.	Cost per square yard of surface.	Item.	Total cost.	Cost per square yard of surface.
Rough grading	$45.15	$0.0247	Freight on oil	$57.44	$0.0313
Subgrade	48.82	.0266	Hauling oil to road	8.80	.0048
Shoulders	77.84	.0424	Heating and applying oil	24.52	.0133
Quarrying, labor	86.84	.0473	Hauling, screening, and spreading sand	8.80	.0048
Quarrying, explosives	51.31	.0280	Rolling (including cost of coal)	47.56	.0258
Loading and hauling	179.80	.0980	Incidentals and supervision	52.41	.0286
Spreading base course	10.00	.0055			
Screening limestone for wearing course	42.05	.0230	Total cost	858.05	.4674
Spreading wearing course	8.65	.0047	Total (exclusive of shoulders)	780.21	.425
Asphaltic oil, 1,801 gallons, f. o. b. Baltimore, Md	108.06	.059			

TABLE 47.—*Cost data, sand-asphalt.*

Item.	Total cost.	Cost per square yard of surface.	Item.	Total cost.	Cost per square yard of surface.
Rough grading	$34.80	$0.0282	Spreading mixture	$39.56	$0.0320
Subgrade	25.01	.0203	Hand rolling	5.45	.0044
Shoulders	119.60	.0969	Power rolling	20.75	.0168
Asphalt, 21.77 tons, including freight	418.70	.3393	Total cost	1,318.05	1.0681
Hauling asphalt (3¼ miles)	14.77	.0120	Total (exclusive of shoulders)	1,198.45	.9712
Screening and heating sand	310.00	.2512	Total (exclusive of rough grading and shoulders)	1,163.65	.9430
Heating asphalt	67.02	.0543			
Mixing sand and asphalt	192.09	.1557			
Transporting mixture	70.30	.0570			

SUPPLEMENTARY REPORTS ON EXPERIMENTS PREVIOUSLY REPORTED.

The experiments which were in progress at the beginning of the year have all been described in previous publications of the Office, and reference is made to these publications by number, in the descriptions below. It will be noted that the experiments undertaken at New York, N. Y., and Ridgewood, N. J., in 1910; at Boise, Idaho, in 1910, and at Newton, Mass., in 1908, have all been discontinued. As explained in Department Bulletin No. 257, the reasons for discontinuing these experiments were either that they have proved failures or that subsequent improvements have destroyed their value from the standpoint of furnishing comparable results.

SUPPLEMENTARY REPORT OF EXPERIMENTS AT LEMON CITY, FLA., 1914.

OILS, TAR PREPARATION, CALCIUM CHLORIDE-CORALLINE ROCK.

The original report of the details of construction of these experimental sections was published in U. S. Department of Agriculture Bulletin No. 257.

In July, 1915, a surface treatment of asphaltic material was applied uniformly to all the sections by the county road authorities. The

depression 55 feet from the south end of section 5, reported in Bulletin No. 257, was still noticeable, but had not increased in size appreciably. A few minor repairs had been made by using a mixture of sand and oil and the surface was in very good condition.

SUPPLEMENTARY REPORT OF EXPERIMENTS AT WEST PALM BEACH, FLA., 1914.

OIL, TAR, OIL-ASPHALT, CORALLINE ROCK.

These experimental sections were constructed on the Miami-Quebec Highway, about 2 miles south of West Palm Beach, in May, 1914. The original report giving the details of materials and methods is published in U. S. Department of Agriculture Bulletin No. 257. As shown in Table 9 in that report, the traffic over this road is heavy suburban and the test of the various sections is therefore rather severe.

The work was inspected December 10, 1915, and the condition of the sections at that time was as follows:

Experiment No. 1. (*Residual asphaltic petroleum, 2.3 gallons. Penetration method.*)—This section is in very satisfactory condition. The bituminous material is still viscous, but the exudation and flow of the excess has ceased and the inequalities in the surface resulting from this flow are not sufficient to cause discomfort to traffic. There is no evidence of weakness developing at any point.

Experiment No. 2. (*Refined coal tars, 1.3 gallons. Penetration method.*)—The bituminous material has continued to harden and the surface is becoming pitted, owing to the fact that individual rocks have been broken and worked out of their setting. These pits are small and uniformly distributed and do not cause noticeable vibration in passing vehicles. About 25 feet from the south end of the section a shallow depression has formed. It is due apparently to settling of the pavement and not to wear.

Experiment No. 3. (*Refined coal tars, 1.2 gallons. Penetration method.*)—The proportion of rock exposed in the surface by the removal of the binder under traffic has increased visibly in the past year. These exposed rocks have worn lower than the surrounding areas still coated with tar and the surface is full of small shallow pits. The tar has become very hard and brittle.

Experiment No. 4. (*Residual asphaltic petroleum, 1.4 gallons. Penetration method.*)—The surface is in good condition, but is becoming slightly rough, due to pits where the rock is exposed. The difference in appearance between the part of the section treated with sand and that treated with stone chips is becoming more pronounced.

Experiment No. 5. (*Oil-asphalt, 1.8 gallons. Penetration method.*)—This section has changed little in appearance or condition and has resisted the action of traffic very satisfactorily.

Experiment No. 6. (*Oil-asphalt, 1.5 gallons. Penetration method.*)—The surface of this section is in perfect condition. While the asphalt has gradually hardened it has not lost its recementing power and is very efficacious as a binder.

Experiment No. 7. (*Coralline rock-waterbound macadam.*)—The surface of this section has worn down uniformly over the entire cross section and is nearly 2 inches below the surface of section No. 6, which it adjoins.

SUPPLEMENTARY REPORT OF EXPERIMENTS AT MIAMI, FLA., 1913.

OIL-CORALLINE ROCK.

The original report of these experiments appeared in U. S. Department of Agriculture Bulletin No. 105 and the statement of their condition in January, 1915, was published in U. S. Department Bulletin No. 257. By that time it had become evident that experiments Nos. 1 and 2 were not successful and they were dropped from the record. The remaining experiments were inspected December 11, 1915, and their condition at that time was as follows:

Experiment No. 3. (*Penetration method. 0.6 gallon hot heavy oil.*)—The surface appearance of this section has not changed noticeably in the past year, except for the gradual exposure of a few particles of coralline rock under traffic. The slight inequalities in the surface reported last year remain unchanged. There were no breaks or seriously worn or weak spots.

Experiment No. 4. (*Penetration method. 0.7 gallon cold light oil.*)—This section, which last year had developed only a few worn depressions, is deteriorating rapidly. The binder has become brittle and the tendency of the rock particles to break away and form holes has become general over the entire area. Repairs made with rock only have failed under traffic, but those in which asphaltic material were added have worn satisfactorily.

Experiment No. 5. (*Penetration method. 0.6 gallon hot heavy oil.*)—The worn depressions and holes reported last year have increased greatly in size and number. The bituminous material has lost its cohesive power and is crumbling. Repairs have been made with coralline rock without bituminous material. It is probable that the entire section will be reconstructed during the coming year.

Experiment No. 6. (*Penetration method. 1.0 gallon hot heavy oil.*)—This section is in excellent condition and shows no signs of local failure or undue wear at any point. It is probable that no repairs will be required during the ensuing year.

SUPPLEMENTARY REPORT OF EXPERIMENTS ON ROCKVILLE PIKE, MONTGOMERY COUNTY, MD., 1913.

The original report of these experiments was given in U. S. Department of Agriculture Bulletin No. 105, and report of the first inspection appeared in Bulletin No. 257. The following information covers the history of the experiments up to February 28, 1916:

Experiment No. 1.—Refined Coal Tar, Hot Application.

As expected at the time of the last report, this experiment required re-treatment during the summer of 1915. The work was done between July 12 and 23, using the same bituminous material as in the original treatment. The tar was delivered directly from the stills of the manufacturer in tank wagons, from which it was distributed under steam pressure at a temperature of 165° to 200° F. A nozzle delivering a conical spray was used and steam was furnished by a road roller which also drew the tank wagon. Since unskilled labor only was available, considerable difficulty was experienced in getting uniform distribution. Clean, washed gravel passing a $\frac{5}{8}$-inch mesh was used as covering material over the entire experiment, as it is considered no longer warrantable to continue the use of trap rock on those sections where it was originally used. The characteristics of a typical sample of the bituminous material are here given, Table 48, and the cost data and quantities will be found in Table 55.

At the time of this re-treatment experiment No. 1 was extended northward from station 61+20 to the forks of the road at station 90+75, thus adding 2,955 feet to experiment No. 1 and reducing the length of experiment No. 2 by a like amount. The reason for this is explained later.

At the time of the inspection the surface was practically intact over the area of the original experiment. But owing to the unequal distribution of tar by the conical hand nozzle used, and the consequent rather large variation in the amount of covering material held by the bitumen, the road surface plainly shows a continuous series of arc-like curves. Some of these are little more than visible and produce no marked vibration as traffic passes, but much the greater part are developing as flat ridges, which are decidedly perceptible to the occupants of a vehicle passing rapidly along the road. From present indications the lower areas, where the mat is thinner, are going to wear rapidly, and the amount of repairing necessary will correspondingly increase.

TABLE 48.—*Analysis of refined coal tar used on experiment No. 1.*

Specific gravity 25°/25° C.	1.205
Float test at 32° C. (time)	1′ 48″
Float test at 50° C. (time)	0′ 46″
Per cent free carbon (insoluble in CS_2)	12.65

Distillation:	Per cent by vol.	Per cent by wt.
Water	0.0	0.0
First light oils (to 110° C)	[1] .5	.3
Second light oils (110° to 170° C.)	[2] .7	.5
Heavy oils (170° to 270° C.)	[3] 17.1	15.4
Heavy oils (270° to 315° C.)	[4] 13.7	11.8
Pitch residue	[5] 68.0	72.0
Total	100.0	100.0

Over the extended area of the experiment the surface is already broken in a great many places. Initial weaknesses, which developed over this section when a part of experiment No. 2, are persistent, and much patching has been necessary since a few weeks after the re-treatment in July. The failures are generally distributed over the surface and not confined to any strip. This section has an exceedingly heavy traffic, and during the winter is usually very dirty, owing to the bad condition of the lanes and adjacent roads which deliver traffic to the section.

The section of this experiment in Bradley Lane has been reconstructed as penetration macadam, and is described as a new experiment in another part of this publication.

EXPERIMENT NO. 2.—REFINED WATER-GAS TAR, COLD APPLICATION.

Those sections referred to in the last report, from Norwood trolley station to Edgewood station, as being poorly drained and under considerable strain, became so bad in the spring of 1915 that at the time of re-treating experiment No. 1 with a hot refined coal tar it was decided to extend the re-treatment northward to include the weak part of experiment No. 2.

That part of No. 2 remaining is now in first-class condition. The general failure, especially along the edges, that was so rapid in the early spring of 1914, had no counterpart in the spring of 1915, and during the winter of 1915–16 the experiment has remained in excellent condition. While there are no indications of general failure, the mat is becoming very thin, and it is planned to give a re-treatment during the summer of 1916. The section of this experiment in Bradley Lane has been reconstructed as a penetration macadam and is described as a new experiment in another part of this publication.

[1] Solid. [2] Clear. [3] One-third solid. [4] One-fourth solid. [5] Hard, brittle.

EXPERIMENT NO. 3.—ASPHALTIC PETROLEUM, COLD APPLICATION

During the winter of 1914 the surface cracked and crumbled in places as during the preceding winter, and in many places mud formed. This ironed out under traffic, but the mat was so thin and broken that a second re-treatment became necessary and was applied June 25 to 30, 1915. A short section at the north end was not finished until August 16–18. The work was done by hand, as described in the last report, using the same bituminous material originally applied and torpedo sand similar to that used on experiment 7. Table 49 shows the characteristics of the bituminous material used, and cost data will be found at the end of this report.

TABLE 49.—*Analysis of asphaltic petroleum used on experiment 3.*

Specific gravity, 25°/25° C.	0.932
Flash point, °C.	35
Burning point, °C.	70
Viscosity, Engler, 50 c. c., at 25° C., specific	61.9
Loss, 5 hours, at 163° C., 20 grams, per cent	22.94
Float test of residue at 32° C., time	5′ 53″
Float test of residue at 50° C., time	1′ 22″
Percentage of total bitumen insoluble in 86° B. naphtha	13.67
Fixed carbon, per cent	7.62
Soluble in CS_2 (total bitumen), per cent	99.90
Organic matter insoluble, per cent	.10
Inorganic matter insoluble, per cent	.00
Total, per cent	100.00

This experiment is becoming rough on one hill, where frequent unusual repairs have had to be made, as described in an earlier report. Except for this the surface presents the same characteristics as it did a year ago. During cold weather the mat crumbles rather freely and at the first thaw mud is formed. If traffic is not too heavy and the mud is not displaced the surface mat is restored rapidly as the surface dries and generally assumes its corky nature. If the mud is displaced to any marked degree, as is very likely to happen if there is a snow storm followed by a thaw, then the mat is not restored along the wheel tracks and two broad, shallow ruts are the result. The stone is soon exposed along these ruts and disintegration follows rapidly. At the time of inspection ruts had formed along about 200 feet of this experiment at the same point where they formed in the winter of 1914–15.

It is planned to give this experiment a fourth application early in the season of 1916. Except as noted above, the surface is smooth and in essentially as good condition as at the time of construction.

EXPERIMENT NO. 4.—RESIDUAL ASPHALTIC PETROLEUM, HOT APPLICATION.

This experiment continues to present the best appearance of any of those still carrying the original treatment. No re-treatment was necessary during 1915, but it is probable that one will be required

during the coming summer. The surface has not become so muddy at any time during the winter of 1915–16 as during that of 1914–15. The bumps due to faulty distribution at the time of original treatment are still visible and cause considerable trouble. They have been repeatedly cut and trimmed, but owing to the excess of bituminous material the spots have required top dressing in the hottest weather, and this builds them up again. There has been considerable repair work necessary over all of the experiment, but no place shows marked weakness. Patches made on this experiment are unusually smooth and serviceable, and so far there appears no tendency for the original surface to break or give way around patches.

Experiment No. 5.—Residual Asphaltic Petroleum, Hot Application.

This experiment, like No. 4, shows less tendency to become muddy during thaws, although dampness of subgrade continues to be very noticeable. During the past summer a great deal of patching has been necessary and the breaks have been somewhat more numerous in the bottoms and poorly drained sections than elsewhere, although they have been general. It is now expected that the experiment will require re-treatment during the coming season.

Experiment No. 6.—Water-Gas Tar Preparation, Hot Application.

This experiment required but little attention during 1914, but early in the spring of 1915 it began to break up rather rapidly. The nature of the failure was very similar to that described for experiment No. 2 in 1914. Breaks in the mat at the sides of the road progressed rapidly toward the center and any raw edge of the mat had a tendency to crumble away rapidly. It was always necessary to give immediate attention to patching, and even with care in some instances patches had to be made that extended from the sides nearly to the center of the road and were from 4 to 6 feet long. It finally became necessary to re-treat November 8 to 12. The work was done by contract, using the same type of bituminous material as originally applied and covering with clean, washed gravel passing a $\frac{5}{8}$-inch screen. The contract price was $1,170 or 11.1 cents per square yard. The characteristics of the material used are shown in Table 50 and additional data are given at the end of this report.

Table No. 50.—*Analysis of water-gas tar preparation used on experiment No. 6.*

Specific gravity 25°/25° C.	1.136
Float test at 32° C., time	2′ 11″
Free carbon (insoluble in CS_2), per cent	1.71

Distillation:	Per cent by vol.	Per cent by wt.
Water	0.0	0.0
First light oils (to 110° C.)	0.0	0.0
Second light oils (110° to 170° C.)	0.0	0.0
Heavy oils (170° to 270° C.)	[1] 10.9	8.7
Heavy oils (270° to 315° C.)	[2] 11.4	10.4
Pitch residue	[3] 77.7	80.9
Total	100.0	100.0

The covering was applied somewhat too heavily. This was in a measure due to a desire to prevent excessive bleeding in the spring. Reference to the preceding report will show that the original treatment bled very freely, and already, at the date of inspection (Feb. 28) the re-treated surface became sticky on sunny days. Material is now distributed along the road ready for use at the first indication of stickiness. The surface is in excellent condition now, fully as good as when originally built, and at the date of inspection there was not a break in it.

Experiment No. 7.—Asphaltic Petroleum, Cold Application.

Reference to the last report will show that this experiment was showing signs of weakness in the fall of 1914. It should have been re-treated at that time, as conditions in the spring of 1915 have since clearly shown. The mat was quite generally forced aside or carried away along two broad, shallow ruts when the surface became muddy in the late winter of 1914–15, and in many places the road metal began to ravel. These ruts were from 18 inches to 2 feet wide and frequently the entire hand could be slipped under a straight edge laid across the rut. A very large amount of patching was necessary to put the experiment into condition for a re-treatment. The re-treatment was given June 21 to 23, 1915, using the same bituminous material as in the original re-treatment (Table 51), and covering with torpedo sand, represented by the analysis given in Table 52. The quantities and costs are given in Tables 54 and 55.

At the time of the inspection this experiment was in excellent condition, except on one or two very short sections where the rutting was excessive last spring. The re-treatment application was very light and there appears to be no noticeable accumulation of mat. The experiment will probably require re-treatment late in the summer of 1916.

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[1] Clear.

[2] Clear; showed 10.0 per cent insoluble in dimethyl sulphate.

[3] Hard, glossy. A 315°–350° C. fraction showed 12.5 per cent insoluble in dimethyl sulphate.

TABLE 51.—*Analysis of asphaltic petroleum used on experiment No. 7.*

Specific gravity 25°/25° C.	0.958
Flash point, °C.	32
Burning point, °C.	81
Viscosity, Engler, 25° C., 50 cc. specific	96.8
Loss 5 hrs. at 163° C. 20 grams, per cent	25.57
Float test on residue at 50° C., time	1′ 13″
Per cent of total bitumen insoluble in 86° C. naphtha	5.38
Fixed carbon, per cent	3.60
Soluble in CS_2 (total bitumen), per cent	99.90
Organic matter insoluble, per cent	.08
Inorganic matter insoluble, per cent	.02
Total, per cent	100.00

TABLE 52.—*Mechanical analysis of sand used on experiment No. 7.*

	Per cent.
Passing ¼-inch screen, retained on ⅛-inch screen	10.6
Passing ⅛-inch screen, retained on 10-mesh sieve	5.3
Passing 10-mesh sieve, retained on 20-mesh sieve	10.8
Passing 20-mesh sieve, retained on 30-mesh sieve	9.8
Passing 30-mesh sieve, retained on 40-mesh sieve	13.3
Passing 40-mesh sieve, retained on 50-mesh sieve	12.1
Passing 50-mesh sieve, retained on 80-mesh sieve	20.5
Passing 80-mesh sieve, retained on 100-mesh sieve	5.3
Passing 100-mesh sieve, retained on 200-mesh sieve	2.9
Passing 200-mesh sieve	9.4
Total	100.0

The traffic census has been continued, regular counts being taken every 13 days. The point of observation was changed on June 26, 1915, so as to give better control, and the period of observation was reduced to 16 hours. A tabulation of the maximum and average of each class of traffic for the period between June 26, 1915, and February 28, 1916, is given in Table 53. Traffic south of the census station is on experiment No. 1, that north of the station is on experiments Nos. 2 to 7, inclusive.

TABLE 53.—*Volume and character of traffic on Rockville Pike at the north end of section 1.*

Vehicle.	Sections 2 to 7.				Section 1.			
	Maximum.		Average.		Maximum.		Average.	
	Northbound.	Southbound.	Northbound.	Southbound.	Northbound.	Southbound.	Northbound.	Southbound.
Loaded 1-horse wagon	18	9	8	4	30	13	16	8
Unloaded 1-horse wagon	9	16	5	8	18	27	8	15
Loaded 2-horse wagon	22	16	7	6	59	24	25	11
Unloaded 2-horse wagon	10	22	3	5	15	44	5	17
Loaded 4-horse wagon	1	3	.....	1	2	7	.....	2
Unloaded 4-horse wagon	3	3	.....	.....	6	2	1	.....
1-horse pleasure vehicle	14	15	6	6	30	28	15	15
2-horse pleasure vehicle	1	2	.....	.....	1	2	.....	.....
Saddle horse	19	7	4	4	18	25	7	7
Motor cycle	48	78	16	17	55	71	22	21
Excessively heavy vehicle	2	2	.....	.....	14	5	2	.....
Motor runabout	74	90	24	26	88	104	35	37
Motor touring car	381	528	117	126	442	582	163	169
Loaded motor dray	26	26	15	16	63	43	31	25
Unloaded motor dray	10	13	3	6	17	48	7	15

Tables 54 and 55 show comparative cost data to date for the various experiments included in this project.

TABLE 54.—*Surface maintenance costs of 1913 experiments on Rockville Pike, Montgomery County, Md., to December 31, 1915.*

Experiment No.	Bituminous material.	Date completed.	Length.	Total cost [1] per square yard prior to Jan. 1, 1915.	Surface [2] maintenance per square yard during 1915.	Total cost of surface per square yard to Dec. 31, 1915.	Surface maintenance per mile per year 1915.	Total maintenance per mile for 1 year.
		1913.	*Feet.*	*Cents.*	*Cents.*			
1	Refined coal tar (hot)	Sept. 22	9,060	12.34	15.36	$27.70	$1,129.90	$1,486.49
2	Refined water-gas tar (cold)	Sept. 24	4,425	9.55	9.34	18.89	137.81	202.22
3	Asphaltic petroleum (cold)	Sept. 30	7,400	9.05	11.37	20.42	401.20	529.25
4	Residual asphaltic petroleum (hot)	Oct. 15	7,100	11.28	3.93	15.21	170.20	276.73
5	....do	Nov. 21	6,775	11.30	4.02	15.32	141.78	226.68
6	Water-gas tar preparation (hot)	Nov. 26	6,325	11.71	15.82	27.53	1,200.48	1,270.93
7	Asphaltic petroleum (cold)	Dec. 5	6,689	10.03	10.38	20.41	828.84	894.24

[1] Average for trap and gravel. [2] To December 31, 1915.

TABLE 55.—*Materials and cost data for surface retreatments in 1915 on Rockville Pike, 1913 project.*

Section No.	Bituminous material.	Area of section.	Quantity of material per square yard.			Cost per square yard (cents).	
			Bituminous material.	Gravel.	Sand.	Bituminous material.	Gravel.
		Sq. ft.	*Gallons.*	*Cu. yds.*	*Cu. yd.*		
1	Refined coal tar, hot application	15,000	0.425	0.014	.....	0.038	0.043
3	Asphaltic petroleum, cold application	7,400	.165	.....	0.016	.014	.....
6	Water-gas tar preparation, hot application	10,542	.474	.018	.....	.....	.....
7	Asphaltic petroleum	11,148	.204	.....	.011	.022	.....

Section No.	Bituminous material.	Cost per square yard (cents).					
		Sand.	Cleaning surface.	Applying bituminous material.	Applying sand or gravel.	Supervision.	Total.
1	Refined coal tar, hot application	.....	0.003	0.007	0.015	0.003	0.109
3	Asphaltic petroleum, cold application	0.036	.002	.008	.005	.005	.070
6	Water-gas tar preparation, hot application	.....	.....	.....	.....	.....	[1] .111
7	Asphaltic petroleum	.023	.001	.006	.004	.002	.058

[1] Work done by contract.

SUPPLEMENTARY REPORT OF EXPERIMENTS AT WASHINGTON, D. C., 1912.

TAR PREPARATION AND OILS, SURFACE TREATMENT.

The original report of these experiments was published in Circular No. 99 of the Office of Public Roads, and inspection reports have appeared in United States Department of Agriculture Bulletins Nos. 105 and 257. The following report describes the condition of the pavement before re-treatment, the extent of the repairs during 1915, and the condition of the experiments when inspected on February 25, 1916.

Section No. 1.—Refined Water-Gas Tar Preparation.

Section 1 appeared intact and required neither repairs nor re-treatment during the summer of 1915.

Section 2 raveled locally in some spots to a depth of 2 inches or more. Most of these failures were along the wheel tracks. Only one was at the edge, and this failure was probably due in some measure to defective drainage. The mat was worn unevenly, and over considerable areas was entirely gone. The entire section was repaired with penetration patches, in which an oil asphalt and limestone were used, top-dressed with trap chips.

The cost of patching was:

Labor	$9.50
Materials	8.10
Total	17.60=$0.0155 per square yard.

The section was then re-treated with the same materials originally used. An analysis of the asphaltic petroleum is given in Table 57.

Section No. 3.—Residual Petroleum.

Section 3 had been persistently muddy during the last winter and spring. The oily mud had been forced aside from the prevailing wheel tracks, so that many bare places and depressions existed, and one long rut about 1½ inches deep and 8 to 10 inches wide had developed along the north edge for some 75 or 80 feet at the west end.

Table No. 56.—*Cost of preliminary repairs per square yard.*

Section.	Labor.	Materials.	Total.
1			
2	$0.0084	$0.0071	$0.0155
3	.0109	.0073	.0182
4			

The section was first patched in the same manner as section 2 and then re-treated. To avoid, if possible, the marked deterioration of this section during the winter, the material used on section 4 was selected for this re-treatment, instead of the original material. The cost of repairs was:

Labor	$7.75
Materials	5.18
Total	12.93=$0.0182 per square yard.

SECTION NO. 4.—ASPHALTIC PETROLEUM.

Section 4 remained in generally good condition. It required no preliminary repairs and was re-treated with the material originally used. An analysis of the bituminous material used on section 3 and 4 is given in Table 57.

TABLE 57.—*Analysis of asphaltic petroleums used on sections Nos. 2, 3, and 4, Washington, D. C., 1915.*

	Section 2.	Sections 3 and 4.
Specific gravity 25°/25° C	0.963	0.949
Flash point °C	31	30
Burning point °C	84	70
Viscosity at 25° C., 50 cc. Engler specific	128.4	94.8
Loss, 5 hrs. at 163° C., 20 grams, per cent	23.14	30.51
Float test on residue, 32° C. (time)	2′ 37″	4′ 35″
Float test on residue, 50° C. (time)	1′ 4″	1′ 23″
Percentage of total bitumen insoluble in 86° B. naphtha	5.96	14.03
Fixed carbon, per cent	4.62	7.70
Soluble in CS_2 (total bitumen), per cent	99.94	99.90
Organic matter insoluble in CS_2, per cent	0.04	0.05
Inorganic matter insoluble in CS_2, per cent	0.02	0.05
Total, per cent	100.00	100.00

TABLE 58.—*Quantities and costs of re-treatments per square yard.*

Section No.	Area.	Bitumen.	Sand.	Costs (materials).		
				Bitumen.	Sand.	Total materials.
	Sq. yds.	*Gallon.*	*Cu. yd.*	*Cent.*	*Cent.*	*Cent.*
2	1,129	0.044	0.003	0.0089	0.0044	0.0133
3	711	.229	.007	.0137	.0114	.0251
4	1,330	.150	.007	.0090	.0122	.0212

Section No.	Costs (labor).							
	Sweeping.	Pouring oil.	Brooming oil.	Spreading sand.	Hauling sand.	Superintendence.	Total labor.	Total costs.
	Cent.	*Cent.*	*Cent.*	*Cent.*	*Cent.*	*Cent.*	*Cent.*	*Cent.*
3	0.0018	0.0015	0.0039	0.0012	0.0039	0.0049	0.0172	0.0305
2	.0048	.0014	.0057	.0024	.0046	.0058	.0247	.0498
4	.0011	.0007	.0024	.0012	.0008	.0052	.0014	.0326

At the time of the inspection made on February 25, 1916, the condition was substantially as follows:

Section 1, which was not re-treated during the past season, appeared in no need of re-treatment.

Section 2 had become rough and uneven, owing both to settlement under traffic in extremely wet weather and to disintegration of the surface. One large hole had developed on the south side at a point where traffic entering from Fourteenth Street fails to turn closely enough to the north corner and in consequence shears away the south edge for several feet. This section has also a number of potholes and spots where the mat was entirely worn away. Extensive repairs will be necessary as soon as the weather permits.

Section 3 suffered as usual on account of seepage from the terrace that lies along the south side of the section. An effort was made to drain this section and a small part of section 2, but sufficient funds were not available to complete the work.

Section 4 has remained in excellent condition. Only one small area at the south end has required any attention. The break at this point was due to the impact of traffic passing from the asphalt driveway to the surface treatment.

SUPPLEMENTARY REPORT OF EXPERIMENTS AT CHEVY CHASE, MD., 1912.

BITUMINOUS CONCRETE, CEMENT CONCRETE, OIL-CEMENT CONCRETE, VITRIFIED BRICK, BITUMINOUS SURFACE TREATMENTS ON CONCRETE.

The original report of these experiments was begun in Circular No. 99 of the Office of Public Roads and completed in U. S. Department of Agriculture Bulletin No. 105. Report of inspection made on March 14, 1915, was published in Department Bulletin No. 257. The following report covers the condition of experiments on February 28, 1916.

Experiment No. 1.—Bituminous Concrete, Topeka Specification.

The general appearance of the experiment is the same as at the last inspection. Imperfections then noted still exist in addition to those noted here. There is one bad break at the north side of the turn into Bradley Lane. Both surface and concrete gutter are broken and indicate some unusual blow. The depression noticed about midway of the section near the curb has increased in size and depth. A second cup-hole 200 feet north of Bradley Lane, near the east side of the road, and a third one, 60 feet from the north end of the limestone section, were noted. In the last 60 feet of this section, 10 or 12 slight imperfections appear. On the trap section a noticeably increasing waviness occurs along the gutter for a width of 2 to 2½ feet.

EXPERIMENT NO. 2.—BITUMINOUS CONCRETE, DISTRICT OF COLUMBIA SPECIFICATION.

This surface continues in essentially the same condition as when last reported. The same cracks were noted and in addition the surface is worn near the curb and gutter, but is generally firm and smooth even in these places. Small pits are to be found quite generally scattered over the south two-thirds of the limestone section. These decrease toward the north end. The expansion joint which was noted in the last report as having failed again buckled in the spring and early summer of 1915. The Portland cement concrete block, 1 foot wide and approximately 18 inches deep, which was put in at this joint was sheared horizontally by the stresses developed and the top 6 inches of the slab was lifted intact from the rest of the block. To repair this joint, all of the broken concrete of experiment No. 3 was removed. The crack limiting the area of failure was from 2 to 4 feet back of the expansion joint. This entire section was re-laid with concrete similar to the original experiment, with a 2½-inch joint left for expansion. This joint was filled with heavy oil puddled with sand.

EXPERIMENT NO. 3.—CEMENT CONCRETE AND OIL-CEMENT CONCRETE; SURFACES TREATED WITH BITUMINOUS MATERIALS.

The surfaces of this experiment have been permitted to wear without repairs and the condition of the various sections at the time of inspection was noted as follows:

(A) *Refined coal tar.*—Twenty to 25 per cent of the surface treatment has worn off this section. The side toward the gutter shows considerably more exposed concrete than the other side.

(B) *Water-gas tar preparation No. 2.*—This area continues slightly better than A, but is deteriorating more rapidly now than during last year.

(C) *Fluxed native asphalt No. 2.*—Eighty-five per cent of the mat is gone on the west half and about 1 per cent on the east half.

(D) *Fluxed native asphalt No. 2 over water-gas tar preparation No. 1.*—About 85 per cent of this treatment has disappeared from the west half and about 5 per cent from the east half.

(E) *Fluxed native asphalt over native asphalt emulsion.*—About 85 per cent of this area is bare on the west half of the road and about 10 per cent on the east half.

(F) *Oil asphalt No. 1 over water-gas tar preparation No. 1.*—A few scattered patches only of the surface treatment remained.

(G) *Refined coal tar.*—The surface treatment is worn off to a great extent over the entire section.

(H) *Water-gas tar preparation No. 2.*—Seventy-five per cent of the surface is worn off from the west half but the east half remains almost intact.

(I) *Fluxed native asphalt No. 2.*—About 60 per cent of the treatment is gone from the west half but the east half remains almost intact.

(J) *Oil asphalt No. 2.*—About 35 per cent of the surface treatment is gone from the west quarter of the road. The remainder is almost intact.

EXPERIMENT NO. 4 (OIL-CEMENT CONCRETE) AND EXPERIMENT NO. 5 (CEMENT CONCRETE).

During the interval of another year there appears to have developed a slight difference in the wearing of the two classes of concrete. On the gravel, limestone, and trap sections, the oil-cement appears to have worn a little more than the cement concrete. The trap section especially has become much rougher for a width of 2 feet along the gutter. The marked difference in the wear on the east and west sides is perhaps more noticeable than at last inspection.

EXPERIMENT NO. 6.—VITRIFIED BRICK.

There is no plainly visible difference in wear between the several sections of this experiment.

A traffic census has been taken on this road every thirteenth day for a 16-hour period. A tabulation of the maximum and average for each class of traffic from March 8, 1915, to February 22, 1916, is given in Table 59. The west side of the road carries south-bound traffic coming from the railroad and the east side carries north-bound traffic toward the railroad.

TABLE 59.—*Volume and character of traffic on Connecticut Avenue north and south of Bradley Lane and on Bradley Lane.*

Vehicle.	North.				South.				Bradley Lane.			
	Maximum.		Average.		Maximum.		Average.		Maximum.		Average.	
	East side.	West side.	East side.	West side.	East side.	West side.	East side.	West side.	East-bound.	West-bound.	East-bound.	West-bound.
Loaded 1-horse wagon	6	22	2	13	18	14	9	8	14	10	5	4
Unloaded 1-horse wagon	8	20	2	10	17	17	7	8	12	14	5	5
Loaded 2-horse wagon	12	82	5	34	21	88	9	32	30	12	10	6
Unloaded 2-horse wagon	55	34	14	16	80	12	30	4	8	19	1	7
Loaded 4-horse wagon	2	4	0	1	3	3	1	1	3	2	1	0
Unloaded 4-horse wagon	1	1	0	0	1	1	0	0	0	1	0	0
1-horse pleasure vehicle	5	16	1	7	15	10	7	5	11	13	4	4
2-horse pleasure vehicle	0	3	0	0	5	3	1	0	3	3	0	0
Rubber-tired horse vehicle	0	0	0	1	1	0	0	0	0	0	0	0
Saddle horse	10	50	2	3	10	13	3	3	5	43	1	3
Motor cycle	6	35	1	13	22	17	11	9	24	13	8	7
Excessively heavy vehicle	1	9	0	1	5	5	1	1	2	3	0	1
Motor runabout	22	136	4	59	171	120	70	47	67	66	25	28
Motor touring car	84	589	10	211	546	502	242	169	300	264	85	95
Loaded motor dray	32	81	2	34	53	39	30	23	22	29	13	16
Unloaded motor dray	13	33	1	12	20	32	6	10	10	9	4	4

MAINTENANCE DURING 1915.

Repairs on these experiments, together with the total cost of each experiment to December 31, 1915, are shown in Table 60.

TABLE 60.—*Surface maintenance costs of 1912 experiments at Chevy Chase, Md., to December 31, 1915.*

Experiment No.	Date completed.	Area.	Maintenance cost of experiment.			Total cost per square yard (cents.)		
			Total for projects to Dec. 31, 1914.	1915	Total.	Construction.	Maintenance.	Total.
		Sq. yds.						
1	1912	1,498	.....	$3.25	$3.25	186.62	0.22	186.84
2	...do....	1,400	$4.11	3.55	7.66	195.65	.55	196.20
3	Spring, 1913	2,837	1.03	2.54	3.57	[1] 142.12	.13	142.25
4	...do....	3,019	2.15	18.35	20.50	[1] 151.21	.68	151.89
5	...do....	3,013	2.07	20.66	22.73	[1] 143.13	.75	143.88
6	...do....	2,055	1.36	.41	1.77	258.21	.08	258.29

[1] Weighted average price for different aggregates.

SUPPLEMENTARY REPORT OF EXPERIMENTS AT CHEVY CHASE, MD., 1911.

BITUMINOUS CONSTRUCTION AND SURFACE TREATMENT.

The original reports of these experiments are given in Circulars Nos. 98 and 99, Office of Public Roads, and supplementary reports appear in U. S. Department of Agriculture Bulletin No. 105, and again in Department Bulletin No. 257. The following report is based upon an inspection made February 28, 1916.

SECTION NO. 1.—REFINED COAL TAR, PENETRATION METHOD.

At the time of the inspection this experiment presented a surface almost intact, except at the narrowest part on the curve, where traffic is much concentrated. Here the mat is wearing off in sections. The experiment is becoming somewhat rough along the gutter on the west side, due probably to failure of the foundation. A similar condition is noticeable in many of the sections of this project.

SECTION NO. 2.—REFINED COAL TAR, MODIFIED GLADWELL METHOD.

The condition of this section continues about the same as when last inspected, except for a slightly increased roughness along the gutter edge.

SECTION NO. 3.—FLUXED NATIVE ASPHALT, PENETRATION METHOD.

Wear on this section continues along the line indicated last year. Those areas which were without mat at the time of the last inspection are quite generally marked with small pits which are adjacent to large particles of exposed aggregate.

SECTION NO. 4.—GILSONITE OIL-ASPHALT, PENETRATION METHOD.

The mat on this section is nearly gone and during the summer, especially on the north half of the experiment, heavy patching was necessary. From indications it is probable that similar heavy patching will be required on the south half during the coming season. Disintegration has appeared along the gutter, due to foundation failure. The mat is decidedly lacking in uniformity, but where the mat is gone the stone is generally well bonded and is wearing smooth, except along the gutters and near the south entrance to the Chevy Chase Club. At this latter point several areas of approximately 1 square foot each are a mass of small cracks, although the mat still covers the stone. These spots are probably evidence of foundation weakness.

SECTION NO. 5.—OIL-ASPHALT, PENETRATION METHOD.

On the east side of the car tracks this section is in generally good condition. The mat is becoming very thin, however, especially on that half of the road toward the gutter, and the stone is exposed over large areas; but the aggregate appears well bonded, and the exposed faces are wearing smooth without much tendency to ravel. On the west side, while the road is much more worn and has been heavily patched, especially toward the south end, it is now practically intact, although rough.

SECTION NO. 6.—OIL-ASPHALT, PENETRATION METHOD.

This experiment has the general appearance of section 5. The east side is worn somewhat more evenly than 5, and the stone is more generally exposed, but there is no tendency to ravel. A seal coat should be given in the spring. On the west side the surface is less uniform and is badly pitted and rough for about 50 feet along the gutter near the north end. This is probably due to foundation failure, as mentioned in other sections. The location of this experiment was such that at the extreme north end traffic passed over it in almost every possible direction. The main entrance to the Chevy Chase Club, a brick crossover on the suburban trolley tracks, the turnout to Bradley Lane, and the fact that from this point northward Kensington Road is surfaced on only one side, while to the south it is surfaced on both sides of the tracks, were conditions that brought such unusual traffic on the extreme end of this section as to wear it very seriously. The adjacent experiment and the brick crossover are much more resistant types of surface than the penetration experiment. This contrast is brought out by the fact that over an area of 12 to 15 square yards the penetration experiment was worn from 1 inch to 2½ inches below grade. During the past summer it became necessary to remedy this condition and it was done by

scarifying a section about 40 feet long so as to include the entire Chevy Chase Club entrance, then using the scarified material as a base and laying a new wearing surface of bituminous concrete of the analysis given in Table 61. A sample of the fluxed native asphalt used in the mixture gave the analysis shown in Table 62. At the time of inspection this intersection was in perfect condition. The total area of the intersection, as rebuilt, was 100 square yards, and the work was done by contract at a cost of $150.

TABLE 61.—*Analysis of bituminous concrete used in resurfacing a portion of section 6.*

	Per cent.
Bitumen soluble in CS_2 (total bitumen)	9.5
Mineral aggregate passing ¾-inch screen, retained on ½-inch screen	2.0
Mineral aggregate passing ½-inch screen, retained on ¼-inch screen	11.0
Mineral aggregate passing ¼-inch screen, retained on ⅛-inch screen	15.3
Mineral aggregate passing ⅛-inch screen, retained on 10-mesh sieve	5.6
Mineral aggregate passing 10-mesh sieve, retained on 20-mesh sieve	14.1
Mineral aggregate passing 20-mesh sieve, retained on 30-mesh sieve	9.7
Mineral aggregate passing 30-mesh sieve, retained on 40-mesh sieve	9.3
Mineral aggregate passing 40-mesh sieve, retained on 50-mesh sieve	7.4
Mineral aggregate passing 50-mesh sieve, retained on 80-mesh sieve	11.5
Mineral aggregate passing 80-mesh sieve, retained on 100-mesh sieve	2.8
Mineral aggregate passing 100-mesh sieve, retained on 200-mesh sieve	3.7
Mineral aggregate passing 200-mesh sieve	7.6
Total	100.0

TABLE 62.—*Analysis of fluxed native asphalt used in bituminous concrete, section 6.*

Specific gravity, 25°/25° C	1.070
Melting point, °C	55
Penetration 25° C. 100 grams. 5 seconds	50
Loss at 163° C. 5 hours, 20 grams, per cent	2.51
Penetration of residue as above	22
Per cent of total bitumen insoluble in 86° B naphtha	26.72
Fixed carbon, per cent	12.52
Soluble in CS_2 (total bitumen), per cent	94.85
Organic matter insoluble in CS_2, per cent	1.80
Inorganic matter insoluble in CS_2, per cent	3.35
Total, per cent	100.00

SECTION NO. 7, A AND B.—OIL-ASPHALT, PENETRATION METHOD.

Section A is much more distinctly mosaic than B and a little smoother. It has a few potholes and will probably require a seal coat in the spring. The south half of B still retains the mat fairly intact, but it appears to be worn very thin. The surface is full of short, irregular waves, especially on the north half, where there are many bare places and a few potholes. Where cleaned the surface shows a somewhat mosaic appearance and toward the north end becomes noticeably smooth and regular.

SECTION NO. 8.—REFINED WATER-GAS TAR PREPARATION, SURFACE TREATMENT.

This section presents a very un-uniform appearance over most of the area. The aggregate now shows and the surface is ready for a seal coat. This treatment was postponed during the past season only at the expense of considerable repair. In a few places there is a heavy mat that appears to have been pushed up by traffic, but elsewhere the mat is generally worn off.

SECTION NO. 9.—ASPHALTIC PETROLEUM, SURFACE TREATMENT.

During the past season, sections 9 and 10 were re-treated uniformly. At the time of inspection they much resembled each other, but 9 is in better general condition. There are only three or four breaks through the mat and, though wavy and uneven, the surface is nearly intact. The marked difference between the east and west halves of the section is not nearly so great as in No. 10. Table 63 gives an analysis of the bituminous material used, and the cost of this re-treatment is given in Table 64.

TABLE 63.—*Analysis of asphaltic petroleum used on sections 9 and 10.*

Specific gravity, 25°/25° C	0.963
Flash point, °C	31
Burning point, °C	84
Viscosity at 25° C., 50 c.c., Engler specific	128.4
Loss, 5 hours, at 163° C., 20 grams, per cent	23.14
Float test on residue, 32° C. (time)	2′ 37″
Float test on residue, 50° C. (time)	1′ 4″
Percentage of total bitumen insoluble in 86° B. naphtha	5.96
Fixed carbon, per cent	4.62
Soluble in CS_2 (total bitumen), per cent	99.94
Organic matter insoluble in CS_2, per cent	0.04
Inorganic matter insoluble in CS_2, per cent	0.02
Total	100.00

SECTION NO. 10.—RESIDUAL PETROLEUM, SURFACE TREATMENT.

This experiment continues to be the most troublesome section of the entire project. Reference to previous reports will disclose that it has had repeated attention, being once scarified and rebuilt and once re-treated. In the spring of 1915, after having been very muddy during the preceding winter, it had an irregular wavy mat and there were numerous spots where the aggregate was exposed. It rapidly disintegrated at these points and considerable repair work became necessary. Finally, on August 16 to 18, 1915, a second re-treatment, using asphaltic petroleum, was given. This re-treatment was extended over experiment No. 9 and its details are given in the description of that section. At the time of inspection the west half of the section against the track was in fair condition, but

the half along the gutter was muddy and showed a tendency to disintegrate. A line of potholes existed along the middle. Much patching will be required as soon as weather permits. In a few places the road metal is raveling and the winter calks on the horses' shoes have cut entirely through the mat on the east side of the road. It appears from a few breaks just forming at the time of inspection that it is this cutting of the mat which starts the numerous potholes. The cost of this re-treatment is shown in Table 64.

TABLE 64.—*Materials and cost data for surface re-treatments.*

Section No.	Bituminous material.	Area of section (square yards).	Quantity of material per square yard.			Cost per square yard (cents).							
			Bituminous material (gallons).	Gravel (cubic yards).	Sand (cubic yards).	Bituminous material.	Gravel.	Sand.	Cleaning surface.	Applying bituminous material.	Applying sand or gravel.	Supervision.	Total.
9	Asphaltic petroleum, cold application	761	0.197	(1)	0.016	2.6	(1)	3.6	0.1	0.4	0.4	0.4	7.5
10	.....do.....	1,013	.172	(1)	.016	2.4	(1)	3.6	.2	.6	.5	.5	7.8

[1] Not ascertained.

MAINTENANCE DURING 1915.

In addition to the general re-treatments above described, the patrol system of maintenance was continued during the year. Table 65 presents the total cost of this maintenance and the re-treatments, together with the total cost of each experiment to December 31, 1915.

TABLE 65.—*Costs of construction and of surface mainteannce to December 31, 1915, of 1911 experiments at Chevy Chase, Md.*

Experiment No.	Date completed.	Area.	Maintenance cost of experiment.				Construction per square yard (cents).		
			To 1913.	1914 [1]	1915	Total.	Construction.	Maintenance.	Total.
	1911.	*Sq. yds.*							
1	Oct. 31	1,581	$0.00	$91.48	$36.97	$128.45	46.18	8.12	54.30
2	...do.....	705	.00	.00	16.14	16.14	64.42	2.29	66.71
3	Nov. 18	1,555	.00	.00	14.71	14.71	64.69	.95	65.64
4	Nov. 8	1,555	4.05	2.54	40.18	46.77	57.18	3.00	60.18
5	Dec. 2	1,447	262.57	.90	42.03	305.50	58.27	21.11	79.38
6	Nov. 23	1,555	3.47	.00	32.15	35.62	68.22	2.29	70.51
7A	Dec. 5	131	1.43	.45	4.70	6.58	59.96	5.02	64.98
7B	...do.....	848	67.88	1.33	24.50	93.71	54.80	11.05	65.85
	1912.								
8	Aug. 24	1,477	80.64	.00	50.16	130.80	[2] 39.59	8.86	48.45
9	June 4	761	39.65	44.86	63.71	148.22	42.01	19.48	61.49
10	Nov. 22	1,013	19.05	286.62	132.17	437.84	44.31	43.22	87.53
11	Dec. 16	377	.00	.00	.00	.00	81.51	.00	81.51

[1] Differences between these quantities and those appearing in Table 25, page 34, U. S. Dept. Agr. Bulletin 257, are due to a distribution of "General expenses," not made in the earlier table.

[2] The construction costs here shown for sections 8, 9, and 10 are uniformly 32.58 cents higher than those appearing in the original table of costs on page 9 of Circular No. 99. The amount represents the cost of the 2-inch top course of water-bound macadam, and it is added here in order to make the costs of the wearing courses of these sections comparable with the costs of penetration and mixed surfaces on other sections.

A traffic census is taken every 13 days for a 16-hour period. A tabulation of the maximum and average of each class of traffic for the period between March 8, 1915, and February 22, 1916, is the same as that taken for the 1912 Chevy Chase experiments. Each side of the road carried traffic in one direction only.

SUPPLEMENTARY REPORT OF EXPERIMENTS MADE AT JAMAICA, N. Y., 1911.

OIL-CEMENT CONCRETE, OIL-ASPHALT, TAR, AND FLUXED NATIVE ASPHALT.

The original report of these experiments was published in Circular No. 98, and reports of annual inspections and repairs are given in Circular No. 99, Office of Public Roads, and in U. S. Department of Agriculture Bulletins Nos. 105 and 257. The following report relates to the condition of the pavement on January 22, 1916.

Experiment No. 1.—Oil-Cement Concrete.

The bituminous surface treatment is worn away to a very considerable extent. At present the concrete is exposed in many large and small patches, and is generally somewhat worn and potted, especially at the street intersection.

Experiment No. 2.—Cut-back Oil-Asphalt, Mixing Method.

This experiment will not be reported on again, excepting for the easterly 50 feet. It was entirely scarified in October, 1915, with the exception of the easterly 50 feet, shaped and rolled, and then surfaced with 2 inches of asphaltic concrete prepared according to the Topeka specification. The easterly 50 feet is still in fair condition in the center, but is somewhat wavy along the sides.

Experiment No. 3.—Fluxed Native Asphalt, Mixing Method.

This section is in practically the same condition as indicated in the last inspection report. The waves along the north side for the easterly 30 feet have become somewhat deeper and there is a slight waviness appearing along both sides throughout the entire length of the section.

Experiment No. 4.—Refined Coal Tar, Mixing Method.

This section is in good condition for a width of about 15 feet along the center. It has become somewhat wavy along both sides throughout its entire length. On the south side from station 10+68 to the east end of the section for a width of about 5 feet, where the seal coat was worn off last year, the pavement is now crumbling.

EXPERIMENT NO. 5.—CUT-BACK OIL ASPHALT, MIXING METHOD.

From the west end up to station 12+50, with the exception of that part opposite Hardenbrook Street, this section is badly worn out and should be rebuilt. The part opposite Hardenbrook Street is still in fair condition. From station 12+50 to the east end of the section the pavement is fairly good, but the south half of it shows considerable wear and the indications are that this part will need to be rebuilt within a year. No work has been done on this section, except that about six holes were repaired by the borough maintenance crew during the past summer.

EXPERIMENT NO. 6.—OIL-ASPHALT, PENETRATION METHOD.

This section is practically in the same condition as indicated in the last inspection report, except that the seal coat has worn until it has entirely disappeared in some places. A slight waviness is developing along both sides over the entire length of the section. The narrow strip where the seal coat had been picked up last year has healed and is not visible now.

EXPERIMENT NO. 7.—REFINED COAL TAR, PENETRATION METHOD.

This section is still in good condition, with the exception of a strip about 5 feet wide along the south side, where it is disintegrating throughout its entire length.

EXPERIMENT NO. 8.—FLUXED NATIVE ASPHALT, PENETRATION METHOD.

This section is apparently in the same condition as indicated in the last inspection report, except for a small hole 1 foot long and 2 feet wide on the south edge at station 17+60.

EXPERIMENT NO. 9.—OIL ASPHALT, PENETRATION METHOD.

This section appears to be in about the same condition as indicated in the last inspection report, except that the narrow strip where the seal coat was picked up has healed and is not now visible.

In reference to this experimental road and the waviness which has been developing along the sides of all of the bituminous sections, it seems well to call attention to the fact that this road was originally built about 1895 as a plain macadam road 18 feet wide, and about 1905 it was reconstructed and surfaced for a width of 25 feet by widening 3½ feet on each side of the old road. It seems probable that the newer part has not the depth of stone or was not as thoroughly compacted as the 18 feet in the center.

SUPPLEMENTARY REPORT OF EXPERIMENT MADE AT AMES, IOWA, 1910.

OIL-ASPHALT GRAVEL.

The original report of this experiment was published in Circular No. 90, and reports of succeeding annual inspections appear, respectively, in Circulars Nos. 98 and 99 of the Office of Public Roads and in U. S. Department of Agriculture Bulletins Nos. 105 and 257.

The driveway on which this experiment was made is 27 feet wide between gutters, but owing to local conditions traffic is confined practically to the eastern two-thirds of the pavement. Several slight inequalities appeared in the traveled way in 1914, and these were partly eliminated by reshaping the road with a grader. The surface was then treated with a light asphaltic oil, but the effect of this treatment had almost entirely disappeared in December, 1914.

In June, 1915, a similar treatment of very light oil was applied, with no more permanent effect than that of the previous one.

In October, 1915, a heavier asphaltic oil was applied to the traveled portion of the road at the rate of one-half gallon per square yard. This work was done under the direction of the superintendent of the grounds and represents the manitenance the roadway has received since its construction in 1910. When inspected December 10, 1915, the gravel surface was well crowned and was covered with a cushion about three-fourths of an inch thick, slightly wavy, but dense and well compacted.

SUPPLEMENTARY REPORT OF EXPERIMENTS MADE AT KNOXVILLE, TENN.

TAR AND OIL PREPARATIONS.

The original report of these experiments was published in Circular No. 94, and reports of subsequent annual inspections appear in Circulars Nos. 98 and 99, Office of Public Roads, and in U. S. Department of Agriculture Bulletins Nos. 105 and 257. The last inspection was made December 10, 1915.

These experiments consisted of three bituminous macadam sections constructed by the penetration method. The binders used were, for section No. 1 a refined coal tar, section No. 2 a refined tar preparation, and section No. 3 an oil-asphalt. By January, 1913, section No. 1 had raveled throughout its entire area and by November, 1914, had failed completely except for two small areas. Section No. 2 showed only a small number of raveled places in January, 1913, but by November, 1914, had become so seriously pitted that reconstruction seemed necessary. Both sections impeded motor traffic noticeably. Section No. 3, on the other hand, was still in excellent condition.

In the spring of 1915 the county road officials ordered the holes in sections Nos. 1 and 2 filled with crushed stone. After this rock had

been compacted by traffic, a surface treatment of light asphaltic oil was applied to the three sections. Section No. 3 is readily recognized by its smooth, even surface and well-preserved cross section.

As these experiments are no longer comparable as types of bituminous macadam pavement, their behavior will not be reported hereafter.

SUPPLEMENTARY REPORT OF EXPERIMENTS AT YOUNGSTOWN, OHIO, 1910.

SLAG, SLAG AND LIME, SLAG AND WASTE SULPHITE LIQUOR PREPARATION, AND SLAG AND TAR.

The original report of these experiments was published in Circular No. 92 and subsequent reports of anuual inspections are given in Circulars Nos. 94, 98, and 99, Office of Public Roads, and in U. S. Department of Agriculture Bulletins Nos. 105 and 257. The following is a report of the condition of the roadway on December 3, 1915. The sections are discussed in the order of their section numbers, beginning at Mahoning Avenue. With the exception of the tar-slag section, the road was covered with a thin sheet of snow at the time of the inspection, which concealed some of the surface details.

Section No. 1.—Blast-Furnace Slag.

The condition of this section has not changed appreciably during the past year. The surface is somewhat worn and pulverized in the middle of the road and wide, shallow ruts are noticeable in the wheel tracks. These ruts are not so pronounced as in the next two sections, however. Aside from these defects, the surface is smooth, uniformly worn, and free from large protruding stones.

Section No. 2.—Blast-Furnace Slag and Lime.

The general condition of this section is about the same as that of section No. 1. The ruts are somewhat more pronounced, particularly the one on the west side of the traveled way, and a depression, which was evidently due to wear, was noted about 50 feet from the north end of the section.

Section No. 3.—Blast-Furnace Slag and Waste Sulphite Liquor Preparation.

Little change has taken place in the condition of this section during the past year. About 100 feet from the north end two shallow depressions have formed in the wheel tracks, and for 200 feet from the north end the surface is worn and slightly depressed in the middle of the road. The ruts referred to in the two preceding sections extend to the top of the slight grade near the middle of this section. The south half of the section, which lies on the grade, is noticeably better than the north half and is one of the best preserved parts of the entire road.

Section No. 4.—Blast-Furnace Slag and Refined Coke-Oven Tar.

The greater portion of this section was constructed over a deep fill and, as noted in previous inspection reports, initial failure was due to unequal settlement. The surface over the fill and the short stretch to the north has disintegrated and numerous holes and depressions have formed, ranging from a square foot to a square yard in area. The south 50 feet of the section, which has not suffered from settlement, remains practically intact and presents a smooth, true surface. The wearing surface was cut through with great difficulty and it was necessary to use a sharp pick in order to remove a small section for examination.

Section No. 5.—Blast-Furnace Slag.

As noted in former inspection reports, this section is lower at its junction with section No. 4 by about 1½ inches. The ruts in the portion lying in the damp cut remain. The south one-third of the section, which at the last inspection was in very satisfactory condition, has developed two depressions at 165 feet and 135 feet, respectively, from the south end. Both were about 2⅓ inches in depth and showed signs of raveling.

Section No. 6.—Blast-Furnace Slag.

This section has not changed materially during the past year. The ruts are wide and more pronounced than in the preceding sections, but there is less loose pulverized material in the middle of the road. There are two rather deep depressions in the traveled way near the middle of the section and three long, deep ones in the east rut in the north 100 feet of the section. However, there was no evidence of raveling in any of these depressions.

Section No. 7.—Blast-Furnace and Open-Hearth Slag.

The condition of this section has not changed appreciably in the past 12 months. The surface as a whole is firm and well bound and noticeably harder than any of the other sections, except that portion of No. 4 which still remains intact.

Several years ago the fill near the south end of the section settled irregularly and a deep hole was formed. This has not been repaired and continues to be a menace to traffic.

SUPPLEMENTARY REPORT OF EXPERIMENTS AT GARDEN CITY, BUCKLIN, FORD, AND DODGE CITY, KANS., 1908.

SAND-CLAY.

The original report of these experiments is contained in circular No. 90, and reports of subsequent annual inspections are published in Circulars Nos. 92, 94, 98, and 99, Office of Public Roads, and in

U. S. Department of Agriculture bulletins Nos. 105 and 257. The reports for the year 1915 are subjoined.

These roads are maintained by the highway officials of the respective counties in which they are located. They are subject to heavy seasonal traffic, due to the marketing of cereal crops. The usual load is about 80 bushels of wheat or shelled corn hauled in narrow-tired wagons. Loads of 100 bushels are not infrequent.

EXPERIMENT AT GARDEN CITY, KANS.

This road was inspected December 20, 1915. There had been no rainfall in more than 2 months, during which time the roadway was subjected to much heavy horse-drawn traffic, due to the marketing of wheat and corn. This had developed depressions from 2 feet to 4 feet square in the middle half of the road surface at intervals of from 150 feet to 300 feet. The depressions were from 2 inches to 4 inches deep. Where free from holes, the road is well crowned.

The road has been maintained by filling depressions with gypsum clay and by dragging with a 3-bladed steel drag after each rain. The dragging had been done approximately twice a month up to the time of the protracted drought above mentioned. As a consequence the ditches are open, the shoulders are well shaped, the edges of the sand-clay surface are protected from erosion, and the entire roadway has a neat and well-kept appearance.

EXPERIMENT AT BUCKLIN, KANS.

This road was inspected December 20, 1915, and its condition found to be as follows:

Beginning at the southern end of the section for the first one-third of a mile the cross section was flat and two wide, shallow ruts had formed. There were no places where the sand-clay mixture had broken through, but several gave evidence of weakening under the heavy hauling due to marketing the cereal crops.

In the next one-third of a mile the road is in poor condition. Deep ruts have developed throughout this entire distance and in several places have worked through the sand-clay surface. The cross section is flat and ridges which obstruct lateral drainage have formed along the outside edge of the sand-clay surface. The condition of this section is so unsatisfactory that traffic avoids it by going outside the ditch lines.

The remainder of the road, approximately one-third mile, is in fair condition. It has sufficient crown to shed water, the ditches are open, and only a few depressions have formed. The holes in the approach to the south end of the bridge over the Arkansas River, which were reported in November, 1914, had been filled with new material.

The unsatisfactory condition of the road is ascribed to lack of care of the road during and after the very heavy rains of the past summer. The roadway can be saved by the addition of suitable new material and by reshaping the surface.

EXPERIMENT AT FORD, KANS.

This road was inspected December 20, 1915. In the first 100 feet south of the bridge over the Arkansas River the road has become flat. One depression has formed at the end of the bridge and at two other places on the filled approach to the bridge the sand-clay surface has been cut through.

The remainder of the section has been shaped with a road grader, but too much sand was brought upon the surface from the ditches during this process. In consequence the surface has become weakened and two deep ruts have formed under traffic.

The depressions should be filled and a thin dressing of new material applied to the entire surface to take up the excess of sand.

SUPPLEMENTARY REPORT OF EXPERIMENTS MADE AT BOWLING GREEN, KY., 1907.

KENTUCKY ROCK ASPHALT.

The original report of this experiment was published in Circular No. 89, and reports of annual inspections are given in Circulars Nos. 90, 92, 94, 98, and 99, and in U. S. Department of Agriculture Bulletins Nos. 105 and 257. The inspection on which this report is based was made December 13, 1915.

This work has not been repaired or cared for in any respect since its construction. Débris carried or dropped upon it has been swept by rain and traffic into ridges on each side, which interrupt lateral drainage and hold dirt on the surface. Consequently the deterioration has not resulted from traffic only. The failure is most marked in the western one-third, where the surface is full of holes varying from 4 square feet to 12 square feet in area. In the middle one-third of the pavement length there is one large broken area at the south edge which is 4 feet wide by 10 feet long. The eastern one-third of the section is still practically intact. Here the most noticeable defect is a shallow unbroken rut on the south side made by a heavy concentrated load during construction and not entirely eliminated by subsequent rolling. Where the surface is broken the asphalt has disappeared and the rocks are loose. Where the binder has not failed the surface is smooth and hard and firm.

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